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PHYSIOLOGY AND HEALTH

NUMBER THREE

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The Union Series

PHYSIOLOGY AND HEALTH

NUMBER THREE

By Mary H. Hunt.

FOR ADVANCED CLASSES

STUDIES OF THE HUMAN BODY AND OF THE EFFECTS OF ALCOHOLIC DRINKS AND NARCOTICS UPON LIFE AND HEALTH

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ANNOUNCEMENT.

MESSRS. IVISON, BLAKEMAN, AND COMPANY having published, under our advice and supervision, the Union Series of Text-Books on Physiology and Health, comprising—

I.—No. 1—For Primary Classes,
II.—No. 2—For Intermediate Classes,
III.—No. 3—For Secondary Classes,

We take great pleasure in endorsing the same, and in recommending their use as School Text-Books. They not only teach the important truths demanded by recent legislation, but teach them in language adapted to the comprehension of the grade of pupils for which each book is specified.

MARY H. HUNT,

National and International Superintendent Department of Scientific Instruction of the Woman's Christian Temperance Union.

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PREFACE.

Most of our States and Territories now by law require that Physiology and Hygiene be taught in the Public Schools, with special reference to the effects of Alcoholic Drinks and other Narcotics on the human system. Many existing books, prepared to meet the demands of the first enactments on this subject, do not fulfill the requirements of more recent legislation. The present work is designed to teach the essential laws of health, and to comply fully with the most stringent provisions of the enactments requiring this subject taught, by conforming to their primary object, namely: To have the children instructed as to the nature of Alcoholic Drinks and other Narcotics, and the results of their use, and thus to forewarn them against the insidious poisons that are the constant cause of so much misery and crime.

As much of Anatomy and Physiology is taught as is necessary to this end. But these Sciences do

not usurp the space and time that belong to the more important aims contemplated by the requirements which this book is intended to meet.

The endeavor has been to make the physiological instruction clear and sufficient,—the Temperance teachings thorough, and as radical as the whole truth now revealed by modern scientific investigation.

The work throughout has been more or less prepared and wholly supervised by Mrs. Mary H. Hunt, the Superintendent of the Department of Scientific Instruction of the National Woman's Christian Temperance Union, and the Advisory Committee of the same, to whom the publishers are under very great obligations.

NEW YORK, February, 1890.

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PHYSIOLOGY AND HEALTH.

CHAPTER I.

INTRODUCTORY.

I

1. The study of the human body is important for two reasons: First, because it is instructive. We find pleasure and profit in examining a machine ingeniously made for doing a certain work. The body may be said to be a living machine. It has many parts called organs, each having its own work; and these parts all combine in the various actions of a human life. The body is more wonderful and interesting as an object of study than any machine of man's making.

2. Second, the study of the human body is important, because one who has the control and guidance of such a mechanism put into his hands ought to understand it thoroughly. We should not place a man in charge of a locomotive, or an electric battery, who knew nothing of their construction or their working. Still less should we be content to remain ignorant of these bodies whose management is committed to our care. We need to know especially how they can be kept in good health,

and enabled to work to the best advantage. We need not only to receive rules to this end from others; but to know the principles on which these rules rest, and to make rules for ourselves. This knowledge is called the Science of Health, or Hygiene, from *Hygeia*, the fancied goddess of health.

3. Health is that condition in which the body and all its parts are doing their work well. To understand the laws of health, we must know what is the work of the body and of each of its parts. This knowledge is called Physiology. It is plain also that to understand clearly the working of the parts of the body, we must know the form, size, and construction of those parts, and their relation to each other. This is called Anatomy. These three sciences, therefore, are closely joined together, and to know Hygiene you must know something of the other two.

4. Our appetites were given to impel and guide us in supplying the needs of the body. But without knowledge these often lead us astray. We see everywhere people who are injuring their health by bad habits in eating; by unsuitable dress; neglect of ventilation and uncleanliness; and others who are destroying themselves, by gratifying their appetites for enticing drinks. Many who use these drinks were ignorant, when they began this course, of the evil effects of such indulgence. The object of this book is to show how we may take such care of our bodies as will keep them in good health, and also to make plain the nature of alcoholic drinks and other narcotics, and their action on the various organs of the body, and thus to forewarn and forearm those who study these lessons against the danger of their use.

CHAPTER II.

WEAR AND REPAIR.

I

1. Like everything else in this world, the human body wears out with use. Every movement that we make wears it more or less. Talking, and even thinking, wear it; and when we are as quiet as we can be, the act of breathing and the circulation of the blood, and other movements that are going on within us, are still wearing it away.

2. Accordingly, the body is constantly giving off waste particles. The surface of the skin itself wears away. Perspiration passes through the skin, — about a pound and a half (680 grms.) daily. During the same time about two and three-quarters of a pound (1247 grms.) of carbonic-acid gas and water go out in the breath. The natural discharge of the kidneys and the bowels per day will weigh four pounds (1815 grms.).

3. The body of a full-grown man loses in twenty-four hours as follows: —

	lbs.	grms.
Through the skin	1.50	(680)
Through the lungs	2.75	(1247)
Through the kidneys and bowels . .	4.00	(1815)
TOTAL	8.25	(3742)

4. This has been learned by experiments. Of course

the amount of loss would not be the same in everybody. Nor would there be the same loss in the same body at different times. If we exercise more, we perspire more and breathe more rapidly, and the body wears more than if we are quiet. But we all lose something every day.

5. Notwithstanding this daily loss, the body of a healthy man continues at about the same weight from day to day and from week to week, because what he loses daily is made up by what he gains. The body of a healthy child grows heavier, because his daily losses are more than made up by his daily gains. We gain by taking in substances which we find around us.

6. The human body, and the bodies of the lower animals as well, have the wonderful power of taking substances into themselves and making them a part of themselves. The body is like a machine in that it wears out with use; but no machine can repair its own wear and waste as the body can.

7. Those substances which the body takes in to repair its own wear, and to increase its size, are Foods, Drinks, and Air. Foods and drinks are taken into the stomach. Air is taken into the lungs.

8. We cannot live five minutes without air. We can go without drink for several days, if necessary. Men have gone without food for a month. Those who have done this, like the famous Dr. Tanner, and others who have imitated him, have kept very quiet, and taken pains to have the daily losses of their bodies as small as possible. But every day they lose something more than they gain, and would die if they refrained from food much more than thirty days. Probably few people could live as long as that without eating.

9. A healthy man, who maintains the same bodily weight from day to day, loses,—

	lbs.	grms.
Through the skin	1.50	(680)
Through the lungs	2.75	(1247)
Through the kidneys and bowels . .	4.00	(1815)
TOTAL	8.25	(3742)

He gains,—

	lbs.	grms.
Through the lungs	1.50	(680)
Through the stomach and bowels .	6.75	(3062)
TOTAL	8.25	(3742)

He needs about five pounds of food and drink. A child who is growing takes more of food and drink and air than his losses amount to.

Sleep.

II

1. The losses and gains of the whole twenty-four hours are about equal. But they are probably seldom the same during different periods of the same length. When the muscles are working, they are losing faster than they are gaining. When they are at rest, they are gaining more than they are losing. So of the other parts of the body, and so of the body as a whole. While it is active, it is losing substance faster than it is gaining. While it is at rest, it is gaining substance faster than it is losing.

2. If a man were placed in a balance delicate enough to mark the slightest change of weight, the balance would not remain still, but would constantly be rising and fall-

ing. Every breath taken in would weigh it down, and every breath given out would cause it to rise. Every motion he made would lighten him a little, while every mouthful of food would make him heavier.

3. While in various ways we rest during the day, the activity of the body, and especially of the brain, makes the losses so much in excess of the gains, that it is necessary for us to have during a part of each twenty-four hours absolute rest for repairs. This absolute rest is sleep.

4. In sleep, the brain so nearly ceases to act that we lose our consciousness. If it thinks at all, it is only in the disconnected and fanciful fashion of dreams. Sleep has been called by the poets the "twin brother of death." In it we lie unconscious, motionless, and helpless. And yet we are glad to spend one-third of our whole time in this deathlike state. For in sleep our bodily losses are made good. Waste is very much diminished, while from the air and from the food and drink which have been taken, substance is stored up for future use and we awake feeling fresh and strong.

5. An infant sleeps nearly all the time during the first few weeks. Little children need at least ten or twelve hours' sleep in the twenty-four. A grown person should sleep from six to eight hours. It is said that Frederick the Great required only five hours' sleep daily, and that Napoleon Bonaparte, in his military campaigns, took only four hours daily.[1] Those who are watching

[1] Napoleon, it is said, often slept in his chair, and so caught naps at odd times, that added much to the sleep taken while in bed. But no one should attempt to follow such an example. It is too great a risk to health and working ability.

over the sick are sometimes able to go for weeks with but four or five hours of sleep in each twenty-four. But these are exceptional cases. Students and other night-workers may for a time be spurred by ambition or love of their pursuit to live with but little sleep, but they feel the bad effects of such a course sooner or later. The brain which is thus compelled to work, without its hours of rest, soon becomes exhausted, and the student "breaks down." "Nervous prostration" results very commonly from allowing the brain to spend more than its measure of strength.

6. We are creatures of habit in regard to sleep. It is much easier to fall asleep, if the hour for retiring is always the same, than if we are irregular in this respect. The night is the best time for sleep, though many are compelled by their occupations to reverse the order and sleep in the day-time. Many "pleasure-seekers" turn night into day, a practice that is not healthful, even though the number of hours spent in sleep is the same. The light and air of day are better for action, while the darkness and silence of night favor repose. The custom of German cities, where evening entertainments begin at six o'clock, and the doors of all houses are locked at ten o'clock, is a good one.

7. Inability to sleep is a sign of danger, and should always be attended to. It results from unhealthy action of some part of the body, and causes still further disturbance. Whatever leads to it, — overwork, or undue excitement, or irregularity in habit, — should be corrected at once. A warm foot-bath before retiring will sometimes induce sleep. Rubbing with a towel or flesh-brush is another method. When the evening has been

spent in study, a brisk walk of fifteen minutes in the open air will dispose to sleep.

8. These methods are useful, because they withdraw the blood away from the brain to some other part of the body. While the brain is active it contains a very large amount of blood in proportion to its size,—about one-fifth of the total amount in the body. When the time for sleep comes, the blood-vessels grow smaller, and the amount of blood is lessened. At the same time the drowsy feeling comes over us, and it is hard to keep from falling asleep. Observation of cases, in which a piece of the skull has been removed, show that while we are sound asleep the brain is pale and comparatively bloodless.

9. In various disordered conditions, the blood-vessels of the brain do not contract as they should when sleep is needed. The blood continues to pour through in full tide, and sleep does not come.

10. In *delirium tremens*, one of the diseases caused by alcohol, the excited brain is full of dreadful images, and sleep is banished for days, until the paroxysm ends in recovery or death.

11. Since sleep is so essential to life and health, and since so much of our time—nearly one-third—is spent in sleeping, the bedroom is an important part of the house. It should be well supplied with fresh air. It should be dry. It should not be exposed to any noxious vapors, like those which arise from a wet cellar, with decaying vegetables in it; or from a cess-pool, or sewer, or other foul spot. One source of danger in cities is the pipe in the stationary wash-bowl connecting with the sewer. If this is not properly trapped and venti-

lated, poisonous gases come up through it. Bedding and the clothes worn at night should be thoroughly aired in the day-time.

III

Object of Eating and Drinking.

1. The object of eating and drinking is the maintenance of physical health and strength. True, it is a pleasure to every healthy person to eat and drink at proper times. The Creator has made it so, in order that we might never fail to do these very necessary acts. If we were not impelled to them by our appetites, we would often neglect them when we are absorbed in some interesting pursuit. But we ought not to eat or drink simply for pleasure. Many things are pleasant to the taste which are unwholesome. And we are also often tempted to eat too much.

2. Each one should observe what kinds of food are injurious to himself, and decline them. Highly stimulating foods, alcoholic beverages, and tobacco, which injure the body, and do not repair its losses, should be absolutely avoided.

3. Many people eat more than they need. In consequence of this, they become fat and dull; or if their stomachs are not strong, they suffer from a feeling of discomfort after meals. Such persons generally indulge in rich and dainty dishes, which entice them to continue eating after their natural appetites are satisfied. The remedy for this is to adopt a plain diet.

4. Many people undoubtedly eat too little. Those whose health is not good frequently lose their appetites, and need to make an effort to eat enough to repair their

losses. Delicate children must sometimes be pressed to eat. But it is a mistake to coax them with pastry and sweetmeats. These, by overtaxing a weak stomach, will increase the difficulty. Busy men and women often give too little time to eating and sleeping. This is as poor policy as it would be for a locomotive engineer to drive past the station, where he should get his supply of coal and water, because he is in a hurry.

Alcohol.—Waste and Repair.

5. For many years it was considered that alcoholic liquors of various kinds helped in repairing the waste, and aided in building up the tissues of the body. Now it is known that alcohol is not only incapable of doing such things, but that its injurious action on various organs prevents the body from being properly nourished by real foods.

QUESTIONS.

I

1. What wears out the body?
2. What evidence have we of wear and waste in the body? By what channels does waste matter go out of the body?
3. What is the daily loss of the body through each of these channels?
4. Is the amount of loss the same in everybody? Is it the same every day?
5. Why does not body-weight constantly diminish?
6. How is the waste of the body repaired?
7. What substances serve to repair the waste of the body?
8. For what substance have we the most constant and pressing need?
9. Repeat the table of bodily losses and gains.

II

1, 2. Do losses and gains maintain a constant balance?

3. What is the object of sleep?

4. In what condition are we during sleep?

5. How much sleep is necessary?

6. What is the best time for sleep?

7. What are the causes and the consequences of inability to sleep?

8. How may we induce sleep? Explain the methods.

9, 10. What diseases banish sleep?

11. What conditions should be secured for our bedrooms?

III

1. What is the object of eating and drinking?
2. What articles of food and drink should be avoided?
3. How may we guard against overeating?
4. Is there any danger of eating too little?
5. Does alcohol repair waste tissue?

CHAPTER III.

CHEMISTRY OF THE BODY.—FOOD.

I

1. Chemistry tells us that all material things are made of about seventy simple substances, called "elements." Every object that we are acquainted with is composed of two or more of these elements. The chemist, in his laboratory, can analyze or break up into its elements any substance, and can tell what these elements are, and how much of each element there is in it. This is as true of animal bodies as of vegetable or mineral matter. A piece of meat or bone can be analyzed as well as a stone or a stick.

2. So it has been found that of the chemical elements only fourteen enter into the human body. These are:

	Parts in 100.		Parts in 100.
Oxygen	72.00	Calcium	1.30
Hydrogen	9.10	Sulphur	.1476
Nitrogen	2.50	Sodium	.10
Chlorine	.085	Potassium	.026
Fluorine	.08	Iron	.01
Carbon	13.50	Magnesium	.0012
Phosphorus	1.15	Silicon	.0002

Traces of several other substances, as manganese, copper, lithium, etc., are found in the body, but they are not constant.

3. When the chemist analyzes the substances which we use as food and drink, he finds that they are all made of the same elements that compose the body. Since we eat for the purpose of restoring to the body what it loses by daily wear, it is to be expected that we should eat things that contain the elements that are lost.

4. In truth, we eat no other things. The elements that are not found in the body do not enter into our foods. Gold, silver, mercury, and zinc, for example, are elements which are not found in the human body, and they poison us if they are mixed with our food, though they are sometimes used as medicine.

5. All our foods and drinks are made of the same elements that compose the body.

6. These elements are more abundant in nature than all the rest. They are found everywhere in the earth, in the air, and in the water, as well as in plants and in animals. And yet men often starve for want of them while they are surrounded with them. It is only as they are found in certain plants and animals that we can use them as food. There is plenty of carbon in a tree, and carbon is one of the needed elements. But we cannot eat wood. The air contains in a hundred parts seventy-nine parts of nitrogen, and nitrogen is absolutely necessary for the maintenance of our lives. But we cannot get it from the air. The lower animals can use many things as food which we cannot use, because they have powers of digestion that we have not.

7. The food of mankind, and all the lower animals, must not only contain the needed elements,—it must contain them in the form of vegetable or animal food. We cannot subsist upon earth, air, or water, alone.

8. And yet the elements which compose our food came originally from the earth, air, and water. Plants have the power, which animals have not, of feeding on earth, air, and water. They take up from these three sources the elements that they need, and make them a part of themselves and grow and thrive upon them.

9. So the plants do the great work of preparing our food for us. All the food of all the lower animals and of man is first drawn from the earth and air and water by the plants.

II

Organic and Inorganic Substances.

1. Of the elements already named which enter into the body of man, four are more abundant than all the rest. These four are carbon, hydrogen, nitrogen, and oxygen, which are indicated in chemical language by the letters C H N O. Ninety-seven parts in a hundred of the body of man and the lower animals consist of C H N O.

2. Accordingly, our food is made chiefly of the same four elements. The remaining elements must be had also. But they are united generally in small proportions in the different substances which make up our diet.

3. The many and diverse articles that we eat are classified according to their chemical composition. The first grand division is into organic and inorganic substances. The inorganic substances are those which we find in inanimate nature as well as in animal bodies, such as water, chloride of sodium (common salt), phosphate of lime, and many other mineral matters. With

the exception of water, these form a very minute part of our daily food. And water and salt are the only inorganic substances that we take clear. The others are all combined in ordinary articles of food. All fruits and vegetables, for example, contain phosphate of lime. Sulphate of sodium and carbonate of potassium are found in most of the grains.

4. The organic substances in the body and its food are those that we do not find in inanimate nature. They exist only in living animals or plants. They are divided into two subdivisions — nitrogenous and non-nitrogenous — according as they contain C H N O, or only C H O.

5. The foods that are chiefly nitrogenous are meats of all kinds. Eggs and milk are largely nitrogenous. The foods which are for the most part non-nitrogenous are all grains, vegetables, and fruits. The non-nitrogenous foods are again divided into starches, sugars, and fats.

6. To recapitulate, we have in the body and in its food the following classes of substances: —

Inorganic.		Water. Salt. Phosphates. Carbonates. Sulphates.
Organic.	Nitrogenous.	Meat, fish, eggs, milk, and other animal foods.
	Non-nitrogenous.	Starchy foods, (as the grains, which contain some nitrogen) sugars, fats.

7. In most articles of food these classes are mixed. Wheat, for example, contains some fat and some nitrogenous matter, with much starch. Flour, which is chiefly starch, contains some of a nitrogenous substance, called gluten. While in process of digestion, these substances are separated; they are digested in different parts of the alimentary canal, and are acted upon by different fluids.

III

Animal and Vegetable Food.

1. Some animals, such as the tiger, live only upon other animals. We call them carniverous, which means flesh-eating. Other animals, such as the ox, live only upon vegetable food. We call them herbivorous, which means plant-eating. The carniverous animals have teeth with sharp points and edges, which are fitted for cutting and tearing flesh. The herbivorous animals have teeth which are broad and fitted for grinding. Man has both the cutting teeth and the grinders, and this shows that it was designed that he should eat both animal and vegetable food. He is omniverous.

Animal Foods.

2. Milk is our earliest food, and it contains all the required elements so combined that it is perfectly well adapted to the needs of the growing infant. Bone, muscle, and nerve find in milk the materials which they need for their nourishment and growth. Milk is also a most valuable food in sickness, because it is usually easily digested.

3. Beef, veal, pork, mutton, and poultry are the

meats in general use, though many other kinds would make good food.

4. Of these beef is on the whole the best. Pork and veal are not easily digested, and should be avoided by those who have weak stomachs.

5. Fish contains the same elements as meat. It is less solid, and for that reason more digestible in many cases than flesh-meat.

6. Eggs are very nourishing and palatable. They sustain the young fowl for the first period of its life, and contain all the elements needed for the growth of its body.

7. The oyster is the most popular fish-food in North America. To most people it is a very palatable dish. Raw oysters are more easily digested than fried oysters.

Vegetable Foods.

8. The most important class of vegetable foods consists of the grains,—wheat, corn, oats, barley, rice, etc. Grains are the seeds of the plants on which they grow. In them is stored up the nourishment which is to sustain the tender germ of the plant until it becomes rooted, just as the egg sustains the growing chick until it breaks through the shell. The farmer raises the wheat and the corn, and preserves the ripe seeds, and so the nourishment which the plant, with its roots and its leaves, helped by the rains and the sunshine, has made out of earth and air and water becomes food for man.

9. Wheat is the finest of the grains, and the best bread is made from wheaten flour. Rice is the principal food of one-third of the human race. Corn contains more oil than other grains. Oats, which used to be

regarded as only food for horses, are now, in the form of oatmeal porridge, used as a part of the daily fare of a great number of people. Oats contain more than any other grain, except wheat, of the substance that makes muscle. Fine oatmeal, thoroughly cooked (for three or four hours), is a very light, digestible, and nutritious article of diet. Coarse, half-cooked oatmeal is not healthful food. Well-cooked mush, made of ground whole wheat, is the most nutritious, easily digested, and healthful of foods.

10. Peas and beans contain a great deal of nutritious substances. They are useful for this reason in feeding armies and other large bodies of men. But both are difficult of digestion for a stomach that is not strong and healthy.

11. The potato originated in South America, and is a comparatively new vegetable. It was not known in Europe until the sixteenth century, and has only been extensively used for the past two hundred years. Now it is cultivated wherever the climate will permit. It is light, palatable, and easily digested.

12. There are many vegetables which are used, not so much for the nourishment they contain, as for their pleasant taste and the healthy action of their juices. Such are turnips, beets, lettuce, and celery.

13. Animal food, as compared with vegetable food, contains a larger amount of substances containing nitrogen. Nitrogen is necessary to the formation of all the tissues of the body, and nitrogenous food is therefore essential. Vegetables, on the other hand, contain a larger proportion of starch. Rice, for example, is 88 per cent. starch. A mixture of animal and vegetable

substances secures a proper combination of nitrogenous and starchy substances for healthful food.

IV

Fats.

1. The custom of eating oil or butter or some purely fatty substance with other food is almost universal. Fat is supposed to be used in maintaining the heat of the body. It helps, too, in the digestion of other articles. But it must be used in moderate quantities, and it is often necessary for those who have weak stomachs to avoid it entirely.

Sugars.

2. Sugar is found in many plants, and is an important article of diet, not only for its agreeable taste, but for its warming and fattening properties. Children are always fond of sugar, and a reasonable amount is healthful for them; but if allowed to gratify their taste unchecked, they frequently use too much of it. It is safer to give them white sugar than to give them colored candies. The coloring matters are sometimes unhealthful.

V

Cooking.

1. Fruits and some vegetables are eaten raw, but the most of our food is cooked.

2. Cooking serves several ends:

(*a*) It makes food more tender and digestible. The harder parts of meats and vegetables are softened, and

the fibers are separated so that they can be more easily masticated or chewed, and the digestive juices can penetrate them.

(*b*) It develops pleasant flavors. The smell of well-cooked meats arouses the appetite and makes the mouth water, while the odor of some meats uncooked would be repulsive.

(*c*) Meats, and sometimes other foods, may contain parasites, which will affect those who eat them injuriously. In countries where raw meats are eaten, many people suffer from tape-worms. Thorough cooking is a perfect safeguard against this danger.

3. It is very important that the cooking should be properly done. The stomach is injured by trying to digest poorly cooked food.

4. If bread or cakes are "heavy," they are hard to digest. If meat is overdone, the nutritive juices are cooked out of it and we lose them. If too much fat is used, and especially if it is fried into food, it forms a coating over each particle which resists the action of the juices of the stomach. Good cooking makes food so attractive that the appetite is stimulated, and so digestion is aided. Since all our strength is derived from our food, the art which prepares it properly and adds to the pleasure of the family table, is not beneath the attention of any one. The custom which is prevalent in many places of leaving this fine art wholly to unskilled servants should be abandoned.

5. A young maiden should not only know how to make good bread, but she should be taught how to cook and prepare in a healthful and attractive manner the various kinds of food that are necessary to best sustain

health and strength. The lad who learns to cook will not become less manly for having such knowledge, and he will thereby be better able to meet many emergencies that are common to every-day life.

Baking.

6. In order to make good bread, we must have — (1) good flour; (2) thorough kneading; (3) good yeast; (4) good judgment exercised in keeping the rising mass just warm enough and letting it rise just long enough; in having the oven just hot enough, and taking out the bread at just the right time.

7. Good bread is light and sweet. Bread is light when the carbonic-acid gas formed in the fermentation caused by the yeast has worked through the whole loaf, making innumerable holes and pores in it. When such bread is eaten, the digestive juices easily enter these pores, and spread through and act upon every part of it. While bread is baking the carbonic-acid gas escapes.

8. Bread is heavy when carbonic-acid gas has not penetrated the mass, either because the yeast is poor or because it has not been thoroughly kneaded. Such bread makes in the stomach a solid lump, which the digestive juices cannot easily enter, and that organ becomes weary and sore in struggling with it.

9. Bread is sour when fermentation has gone on too long, in which case an acid is formed in it.

10. Pastry and cake should be eaten only in small quantities, and some people should not eat them at all. They contain too much sugar and butter in proportion to other nutritive matters to be eaten freely.

VI

Mineral Substances

1. Mineral substances are mingled with all our food. Salt is the only solid mineral matter that we take pure. It enters into every part of the body, solid or fluid, and aids the processes of life.

2. Mineral substances are not commonly changed by digestion.

Eating and Drinking Habits.

3. The eating and drinking habits of mankind vary greatly. They are modified by the climate, and by surroundings. The Esquimaux drink fish-oil and eat candles with a relish. The Hindoo lives upon rice. The Arab supports life, and performs great journeys on a handful of grain a day. The European or American requires a better kind of food. The human body can adapt itself wonderfully to its circumstances. But the people of those nations, which, by reason of their geographical situation and their wealth have been able to obtain the best and most varied diet, have the strongest bodies.

4. There is is also an endless variety in the habits and tastes of members of the same race or community. Some prefer one kind of food and some another. Some eat two meals a day and some three. Constitutions, habits, and circumstances make great differences. One man may thrive on food that would destroy another. A brain-worker may accomplish most and feel best if he eats little until noon; a day-laborer would lose his vigor under such a practice. One man is overfed by a flesh-meat diet, while another ought to live chiefly on

meats. If nature had not made mankind capable of such variations, the work of the world could not be done.

5. A healthy appetite is nature's guide to right habits of eating and drinking. But nature intended that our appetites should be controlled and regulated by reason. Every person should adopt that course which is best suited for him.

6. When large bodies of men have to be fed, as in an army or navy, it becomes necessary to find out just how much of each kind of food a man requires daily. By combining physiological reasonings with experiment, Professor Dalton found that for a man in health, taking exercise in the fresh, open air, the following was a sufficient daily ration:—

	oz.	grms.
Meat	16	(453)
Bread	19	(540)
Butter	3½	(100)
Water	54	(1530)
TOTAL	92½	(2623)

Total: water, 3 lbs. 6 ounces; solids, 2 lbs., 6½ ounces.

Men at hard labor require more, and those who are entirely inactive less.

VII

Alcohol not a Food.

1. Alcohol contains no nitrogen, and must therefore be excluded from the nitrogenous foods. When taken into the body it does not raise the temperature. On the contrary, it causes a reduction of bodily heat as will be hereafter shown (page 187).

2. A true food increases strength of muscle. Alcohol diminishes muscular strength. Sometimes, during a storm at sea, sailors are given rum or whisky to help them endure the extra hardship. For a short time after taking it they appear more active, but in reality are weaker. They cannot endure so long a strain on their muscular power or vitality as those working under the same circumstances who take no alcohol.

3. Neither can alcohol be classed with the salts which regulate the passage of liquids through the tissues, nor with water which is the great solvent and carrier of the body. The action of alcohol is directly antagonistic to the work done by either of these. Instead of rendering the tissues more soft and pliable and in better condition for the transmission of food and waste, it hardens them.[1] It also irritates, inflames, and may cause destructive changes.

4. All true foods satisfy the appetite when enough for the needs of the body has been taken.[2] The body needs no alcohol, and it is the nature of alcohol to create an appetite for itself that can never be satisfied.

[1] If a piece of meat be left in alcohol for a few hours it will be found much harder than when it was put in, because alcohol has taken the water from it. In certain experiments where it is desirable to extract the water from dead animal substances, as the mucous membrane of the stomach, this is accomplished by immersing the substance for a short time in alcohol.

[2] "If a person eats bread three times a day for twenty years, he is just as readily satisfied at the end of the time as he was at the beginning. Natural appetite, or hunger, is simply the demand for material to supply the growth or waste of tissue. Every substance capable of assimilation will satisfy that demand, and with that satisfaction, ceases for the time being, all relish for more."—Davis: *Practice of Medicine*, page 34.

5. It has been laid down as a principle by eminent physiologists that "any substance, in order to be considered a food, must not be injurious to the structure or action of any organ, otherwise it is a poison, not a food."[1] Alcohol is injurious to the structure and action of various organs of the body, and therefore cannot be properly classed with foods.

VIII

Natural Drinks.—Water.

1. Water forms about seventy of every hundred parts in the body. It must be constantly supplied, therefore, to provide for the growth and make up for the waste of the parts. Digestion, absorption, and circulation would stop without water. The craving for it is stronger than for food. We are therefore drinking beings, and it is necessary to our health and usefulness that we take the right kind of drinks. What these are is an important inquiry. The living bodies of men and the lower animals, as we have seen, are so formed that water is the fluid by which their thirst is assuaged, and by which they may live.

2. Water serves four important purposes in the body,—

(*a*) It keeps the tissues moist and flexible. A piece of dry glue is brittle, and will break if you attempt to bend it; allow it to soak up a portion of water, and you can bend it in any direction. Much of the solid matter composing the body is gelatinous or glue-like, and has the

[1] Dr. H. Newell Martin: *Human Body*, pages 115–116.

same power of soaking up water, without which it would become too hard to keep up the processes of life. Anything that interferes with the due amount of water in the tissues of the body impairs their power and impedes their action.

(*b*) Water is a solvent for food. The whole process of digestion, as we shall see, consists in reducing food to a liquid form so that it can soak through the delicate membrane of the digestive canal into the blood-vessels. This could not be accomplished without water.

(*c*) Water is a food-carrier in the body. Water makes up the greater part of the blood, and as the blood circulates it carries with it the dissolved food which soaks out of the blood-vessels upon the tissues. The tissues can then absorb the food much as a cloth can soak up sugar, salt, or coloring matter, when these are dissolved in water. If the food were not dissolved in water, the tissues could not soak it up any more than the cloth could soak up dry sugar or dry salt.

(*d*) Water is also the carrier of waste. As we have seen, water constitutes the greater part of the blood, which takes up and carries away from the tissues the worn-out particles that are no longer of use.

3. Pure water is therefore the natural drink of human beings and the lower animals. No other liquid takes the same place.

4. Water used for drinking always contains a small portion of mineral salts, of gases, and of vegetable matter. Water which is absolutely pure — as only distilled water is — is flat and tasteless. The mineral elements in drinking waters are such as are not harmful to the system, unless there is too much of one kind, or too much

of all of them. In that case they are irritating to the bowels and kidneys. When water is carried through lead-pipes, it sometimes dissolves enough of the lead on its passage to become poisonous. Whether it will do that or not depends on what it already contains. Some waters may be carried through lead-pipes with perfect safety, either because the water does not act on the pipe at all, or because certain mineral matters which are in the water form a crust, lining the pipes and protecting them from further action. When lead-pipes are used, the question whether the water acts upon them should be settled by a chemist. Tin-pipes are safer. Water that is constantly running through lead-pipes is less likely to contain much lead than that which stands still in the pipes for a long period. Lead, when taken in small quantities in this way, produces its bad effects very gradually, and health is often seriously affected before the cause is discovered. Among the symptoms of lead-poisoning are colic and paralysis of certain muscles.

5. Offensive and poisonous substances, animal and vegetable, sometimes find their way into drinking water, and being dissolved in it, give no sign of their presence. Sewage and the germs of disease may thus be taken up. It is necessary therefore to guard the well or water-pipes very carefully from all impurities. Wells and reservoirs are often placed where they catch the drainage from barn-yards or other filthy places. Such drainage will go through the soil much farther than is commonly supposed. The fact that water is clear and sparkling and odorless does not prove that it is pure. A well or reservoir should not be located within thirty feet of any sloughy spot. Even at that distance it is not safe, if

the ground is porous and slopes towards the well. In some cases aqueduct-pipes become leaky, and draw in filth. Constant watchfulness against such destroyers of health is necessary.

Milk, Tea, and Coffee.

6. Milk, our first food, is both a food and a drink. Of a hundred parts of milk about eighty-six parts are water. The remaining parts are food materials.

7. People often attempt to improve water for a beverage, by steeping or infusing in it the leaves of the tea-plant or the berry or seed of the coffee-tree. Such drinks are called tea and coffee. It is probable that all persons would be in better health, if instead of drinking tea and coffee, they had always used water or milk—the drinks furnished by nature. Physicians who have studied the effects of tea and coffee agree that they injure children, and that young people are better without them.

8. Cocoa is less injurious than tea or coffee.

General Principles.

9. While it is not necessary that all should adopt the same habits, there are certain principles which should govern all. The following are some of these,—

(*a*) It is injurious to eat tempting food after the demands of a healthy appetite are satisfied.

(*b*) It is important to eat at regular periods only. The stomach needs its regular times for rest.

(*c*) All substances which simply please the palate, without furnishing any nutriment,—such as spices and other condiments,—should be used with caution.

(*d*) Tobacco and alcohol are poisons, and both should be absolutely shunned.

ILLUSTRATIONS.

1. Illustrations of this chapter belong to the department of chemistry chiefly. The teacher can enlarge on the subject by discussing many articles of food, and asking the pupil to classify them.

2. To demonstrate, Section VII., paragraph 3. Soak a piece of meat for twenty-four hours in alcohol, and note the effect.

QUESTIONS.

I

1. What are Chemical Elements? How many are there?

2, 3. How many chemical elements enter into the composition of the body? Name them. What elements compose our food?

4, 5. Are any elements which do not enter into the composition of the body found in our foods?

6. Where are the elements which we require in our food to be found?

7. Can we take the elements that we need for nourishment wherever they are found?

8, 9. How do plants differ from animals in their way of getting nourishment? What service do plants render to animals?

II

1. What four elements are most abundant in the body of man? What proportion of the body do they form?

2. Which of the elements form the larger part of our food?

3. Into what two classes may food be divided?

4. What subdivisions of food may be made?

5. Name some nitrogenous and some non-nitrogenous articles of food.

6. Repeat or write on the board the classification of substances entering into food.

7. Are these substances usually separate or mixed in our food stuffs?

III

1. What is a carnivorous animal? an herbivorous animal? To which class does man belong?

2–7. What can you say of milk as an article of food? of beef, veal, mutton, and pork? of fish? of eggs? of oysters?

8, 9. What is the most important class of vegetable foods? What is grain? Mention some of the different grains used as foods, and state the characteristics of each.

10, 11, 12, 13. What can you say of peas and beans? of the potato? of lettuce, celery, and small vegetables? What class of substances predominates in animal food? in vegetable food?

IV

1, 2. Why is butter a useful article? Why is sugar healthful?

V

1, 2. Why do we cook our food?

3, 4. What is the effect of bad cooking?

5. Why is a knowledge of the art of cookery desirable?

6. What is necessary in order to have good bread?

7, 8. What do we mean by light bread? What is heavy bread?

9. What makes bread sour?

10. What caution is necessary in using pastry and cake?

VI

1, 2. Do we eat mineral substances pure? Are such substances digested?

3, 4. Should all observe the same habits of eating and drinking?

5, 6. What besides appetite should guide us in the matter of eating and drinking? What is a sufficient daily ration for a man?

VII

1. Why cannot alcohol be classed with the nitrogenous foods?

2. How does alcohol affect muscular strength?

3. How does alcohol interfere with the vital action of the tissues?

4, 5. Mention points in which alcohol differs from food?

VIII

1. What is the proportion of water in the body?

2. What four purposes does water serve in the body?

3, 4, 5. What impurities may water contain? Is water which is carried through lead-pipes always poisonous? What are symptoms of lead-poisoning?

6, 7, 9. What kind of food is milk? What is the best course to pursue in regard to the use of tea and coffee? Name four principles which all should observe in eating and drinking.

CHAPTER IV.

ORIGIN AND NATURE OF ALCOHOL.

I

All that Lives must Die.

1. The bodies of plants and animals, as well as the human body, are composed of many elements, which are taken up into the system in the food these bodies absorb or imbibe.

2. The plant receives its food from the ground by means of its roots, and from the air by means of its leaves. It grows to its full size, if it meets with no hindrance, bears its seed, and when it has lived out its appointed time it dies.

All that Dies must Decay or Go to Pieces.

3. The next step in the order of nature after death is the decay or going to pieces of the animal, fruit, or plant. All the minerals, the gases, and other elements that were absorbed in plant, fruit, or animal, to build it up, must now be set free, in order that they may go to build up other living things. Otherwise the surface of the earth would soon be covered with dead trees, fruits, shrubs, grasses, and the bodies of dead animals. There would soon be no room for new growths, and perhaps no materials out of which new growths could be built.

The Cause of Decay.

4. If we leave cheese, bread, or any similar article of food in a damp place, we will soon find it covered over with mold.

5. It was long ago noticed that fruit or other vegetable matter kept entirely away from the air would not decay, and hence the air was supposed to be the cause of the decay. The microscope has shown us that the decay is caused, not by the air itself, but by minute living things in the air belonging to the lowest forms of vegetable life. Among these are the molds and the ferments (which are closely related to the molds), each working upon different forms of matter and producing different kinds of decay.

6. The germs of these molds and ferments, which correspond to the seeds of plants, float about in the air and are invisible to the naked eye. When they find a favorable soil, such as dead animal or vegetable matter, they enter it and begin to multiply rapidly, taking from it the substances which serve them for food. In doing so, they cause the animal or vegetable matter to decay or break up into the elements that compose it. Some of these go off into the air in the form of gas. All of them, sooner or later, as we have seen, enter into new matter often very different in its nature from that upon which the ferments began their work in the first place.

How Alcohol is Produced by Ferments.

7. Imagine that you hold in your hand a bunch of ripe grapes, just picked from the vines. Upon the sur-

face of each grape is a thin coating of dust, called its "bloom," that can be rubbed off. This dust, if examined with a microscope, will be found to contain germs of both molds and ferments.[1]

8. If the grapes are left to themselves the molds will, in time, cause them to decay or rot; but if the grapes are picked, and their juice is pressed out, this juice is caused to decay by the ferments. Ferments work only in the juice of fruit after it is pressed out. They are never found inside the fruit itself,[2] but easily wash off from the surface of the fruit into the expressed

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[1] Pasteur, who is recognized as the greatest of investigators in this field, gives the following account of such an examination: "On September 27th we picked from a vine, in the neighborhood of Arbois, nine bunches of grapes, without injury to a single grape, brought them to our laboratory in a sheet of paper that had been previously scorched in the flame of a spirit lamp to destroy all germs that might adhere to the paper, and the grapes were cut off with a pair of fine scissors, which had also for the same purpose been passed through the flame. By means of a badger-hair brush, thoroughly purified in water, each grape to which a portion of its stem remained attached, was washed in a little pure water. The successive washing of a dozen grapes in a small amount of water was sufficient to make the water turbid; we then examined it under the microscope, and saw many little organized bodies. As a rule the organisms consisted of simple, transparent, colorless cells; some, indeed, of larger size had a yellowish color, and were detached or united in irregular masses; and, lastly, there were club-shaped or bottle-shaped vessels, full of spores, ready to germinate." — PASTEUR: *Studies on Fermentation*, page 152.

By experimenting with these spores and germs, Pasteur proved that some of them were the germs of ferments. When placed in a sweet liquid, which had been previously purified from all other germs, they multiplied and produced alcohol.

[2] PASTEUR: *Studies on Fermentation*, page 235.

juice. Other ferment-germs floating in the dust of the air may fall into it. Ferments, like many other forms of life, could not live without oxygen. When they are resting on the stems or skins of the fruit, or are floating in the air, they obtain their oxygen from the air. When submerged in pressed-out fruit-juice, they take their oxygen from the sugar[1] of such juice. If this juice stands for a short time in a moderately warm place, bubbles of gas will be seen rising through the liquid, and breaking into the air.[2] Each ferment is taking a small portion of oxygen from this sugar, and setting

[1] Most fruits contain some sugar, which forms in them while they are ripening.

[2] With a strong microscope the ferments themselves can be seen in the liquid. They are very small, transparent bodies, without head, legs, or other parts usual to plants or animals. The most remarkable thing about them is the rapidity with which they increase in numbers. From the side of one ferment a bud swells out, which, in about an hour, breaks off and forms a new ferment ready soon to send out new buds.

Pasteur says, "On October 12th, at ten o'clock in the morning, we crushed some grapes, without filtering the juice that ran from them; afterwards at different times during the day, we examined the juice under the microscope, until at last, although not before seven o'clock in the evening, we detected a couple of cells. From that time we kept these cells constantly in view. At 7:10 o'clock we saw them separate and remove to some little distance from each other. Between 7 and 7:30 we saw, on each of these cells a very minute bud originate and grow, little by little. By 7:45 these buds had increased greatly in size. By 8 they had attained the size of the mother-cells. By 9 each couple had put forth a new bud. We did not follow the multiplication of cells any further, having seen that in the course of two hours two cells had furnished eight, including the two mother-cells. This increase would have been still more rapid at a higher temperature."

the gas (carbonic-acid gas) free. As the sugar is thus broken up, a new substance, not at all like sugar, is formed and remains in the juice. This new substance is called alcohol,[1] and is a poison. Its presence makes the grape-juice,—which was healthful before the alcohol was formed,—a poisonous fluid, called wine.

9. We have seen that the alcoholic ferments are not found within the fruit itself, hence there is no alcohol in fruits, grains, or vegetables, as they are prepared by nature for our use.

10. The process by which healthful fruit-juices are turned into alcoholic liquors by the ferments is called *vinous or alcoholic fermentation.*[2] There are several kinds of fermentation, but one law holds good for all, that is, *fermentation entirely changes the nature of the substance it works upon.*

11. Before the nature of alcohol and its effects on the

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[1] There are many alcohols, and all are the result of the fermentation of some organic substance, and all are poisons. Methyl alcohol is derived from fermented wood; Amyl alcohol, known as fusil oil, is derived from fermented potato-juice, etc. But the term alcohol, as ordinarily used, refers only to ethyl, or common alcohol, derived from the fermentation of fruit-juices and certain other sweet liquids.

[2] Fermentation, in its widest sense, includes all forms of decay. But the term *ferments* is commonly restricted to alcoholic ferments. As used in this book the term has reference only to the alcoholic ferments. The botanical name of the genus to which alcoholic ferments belong is *Saccharomyces.* One species of these is found on all ripe garden fruits, and is called *Saccharomyces apiculata.* The species most abundant on the grape, and hence called the ferment of wine, is *Saccharomyces ellipsoëdius.* The ferment of yeast is *Saccharomyces cerevisiæ.*

human system were as well understood as now, people thought that alcohol was a food that would in some way aid health and lengthen life.

During the past few years, however, this treacherous liquid has been more carefully studied than ever before, and those who now best understand its nature and effects unhesitatingly class it as a poison that injures health and shortens human life.

II

Alcohol a Narcotic Poison.

1. A poison is any substance whose nature it is when absorbed into the blood to injure health and destroy life.

2. Poisons that stupefy, deaden or paralyze the brain are called narcotic poisons. Alcohol is a narcotic poison, because it deadens or paralyzes the brain and nerves according to the amount taken.

Alcoholic Appetite.

3. There are many different classes of poisons, some exerting their injurious and destructive effects upon one part of the body in one way, and some injuring other parts in a different way. We have seen that alcohol is a narcotic poison. Narcotic poisons have the power to create an ever-increasing appetite for themselves. Alcohol has this power in a marked degree, and in whatever form or quantity taken. The character of a substance does not depend upon its quantity, but its quality. In whatever liquors alcohol is found, whether in those that

contain much of it, as brandy and rum, or little, as beer, wine, and cider, its character is always the same.

4. When water comes into contact with living tissues they absorb it, and are satisfied. Water is a natural drink and quenches natural thirst. When alcohol is brought into contact with living tissues, it irritates them and creates thirst. For this unnatural thirst there is no natural limit.[1] If more alcohol is taken, it has the power to still further increase the disturbance and rouses a still more imperious demand, that is never satisfied, even when the drinker's arm is paralyzed and he can no longer lift his glass. Even then, in his drunken mutterings, he calls for more, and his first thought on regaining consciousness is again — *more.*

5. Those who witness the ruin alcohol brings to the drunkard are apt to charge his degradation to his weakness in "drinking too much;" but *any* is "too much," because *it is the nature of a little alcohol to create an appetite for more.* Thus, there is a logical and scientific connection between the first glass and the drunkard's fate. It is not the weakness of the drinker, but the nature of the drink that causes drunkenness.[2]

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[1] "Only natural appetites have natural limits. The art of the pastry cook would hardly induce his customers to stupefy and beastialize themselves with his compounds. There are no milk-topers, no suicidal potato-eaters, no victims of a chronic porridge passion." — FELIX OSWALD, M. D.: *The Poison Problem.*

[2] "People sometimes wonder," says Dr. Jennings, "why such and such men, possessing great intellectual power and firmness of character in other respects, cannot drink moderately and not give themselves up to drunkenness. They become drunkards by law — fixed, immutable law. Let a man with a constitution as perfect as Adam's undertake to drink alcohol, moderately and persever-

6. The rapidity with which the craving for alcohol grows upon its victim varies with the individual. Every person who drinks a glass of wine may not become a drunkard, but no one who drinks alcoholic liquors, even in small quantities, can tell how soon they may create in him the imperative appetite, which, resisted, is torture; yielded to, is ruin. Entire abstinence is the only sure preventive against forming the alcoholic appetite, — and the only remedy when such an appetite is formed. Even so small a quantity of alcohol as that in the wine often used to flavor jellies, puddings, sauces, etc., is capable of rousing a slumbering appetite that may have been for a long time repressed. Alcoholic liquors in any form should never be used either as a beverage or as a flavoring for food.

7. Because people have not understood the origin and nature of alcoholic drinks, they have supposed the "lighter liquors," such as beer, wine, and cider, to be harmless. But we have seen the power a little alcohol has to create an appetite for more. This makes any liquor containing it a treacherous as well as a seductive drink.

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ingly, with all the caution and deliberate determination that he can command, and if he could live long enough he would just as certainly become a drunkard, — get to a point where he could not refrain from drinking to excess, — as he would go over Niagara Falls when placed in a canoe in the river above the falls and left to the natural operation of the current. And proportionately as he descended the stream would his appetite for alcohol increase, so that he would find it more and more difficult to get ashore, until he reached a point where escape was impossible." — *Medical Reform*, page 175.

Cider.

8. Perhaps none of the alcoholic beverages has started more people on the road to drunkenness in this country than cider.

9. As in the case of grapes, ferments, too small to be seen by the naked eye, rest upon the skins and stems of apples from which cider is made. When the apples are ground, and the juice is pressed out, some of these ferments are easily washed off into the liquid. If it is moderately warm, they begin at once to break up the sugar of the juice into carbonic-acid gas and alcohol. The gas passes out of the cider in bubbles; but the alcohol remains in it, and whoever drinks the cider gets some of this poison. The ferments multiply so rapidly that alcohol can usually be found in cider within six hours after it is pressed out. From this time on, the amount of alcohol in the cider gradually increases as the ferments continue their work, and the cider is said to be growing hard. Often one part in ten of hard cider is alcohol. One peculiar fact about cider-drinking is, that it tends to make those who drink it ill-tempered.[1]

10. When cider, beer, or wine, or a similar fermented liquor, is left open to warm air, another form of fermentation takes place, which produces vinegar. This is done by a ferment, known as the mother of vinegar, which grows upon the surface of all such liquids, and produces

[1] "The form in which alcohol is taken determines in some degree the character of the mental state it produces. Cider makes the ugliest drunkards."—E. Chenery, M. D.: *Facts for the Millions.*

a fermentation, called acetous fermentation. In acetous fermentation, the alcohol of the wine, or cider, or other similar liquor, is changed to a sharp acid. You remember the law that fermentation changes the nature of the substance that it works upon. Vinous fermentation changes the healthful sugar of sweet liquids to alcohol, which is a poison. Acetous fermentation changes the poison, alcohol, to a sharp acid, totally unlike alcohol in its nature, that may be safely used to flavor food. There is no alcohol in vinegar.

Beer.

11. Beer is one of the so-called "lighter liquors," and was at one time thought to be a harmless drink. But experience and science have both shown it to be far from harmless. It is the product of alcoholic fermentation, and, like other fermented liquors, is poisonous, because of the alcohol contained in it.

12. Beer is usually made from barley, sometimes from other grains. As grain has no sweet liquid necessary for fermentation, this is produced by first sprouting the grain, which turns its starch into sugar; second, heating the grain to stop further sprouting; third, mashing or grinding it; fourth, soaking out its sugar with water; fifth, adding yeast to produce alcoholic fermentation. Yeast is one kind of ferment. Hops give the beer its bitter flavor. The yeast sets up fermentation, by breaking up the sugar into the carbonic-acid gas which bubbles out of the liquid into the air, and to alcohol, which remains in the beer, making it poisonous.

13. Like all poison habits, the habit of beer-drinking is progressive. Beer has the power of creating an

appetite that requires an immense amount of beer or of stronger liquors for its gratification, while it brutalizes and stupefies the drinker in proportion to the amount he imbibes. Beer has been well called "one of the most animalizing of drinks." It obscures the intellectual and moral faculties, while it also arouses the worst passions of human nature. Beyond all other drinks it qualifies for deliberate crime.

III

Distillation and Distilled Liquors.

1. The largest amount of alcohol that can be produced in any liquid by fermentation is about seventeen parts in one hundred. More than this stops the work of the ferments. But men have invented ways of obtaining liquors much stronger with alcohol, and almost pure alcohol itself. Their ability to do this depends upon the fact that alcohol may be turned into vapor at a much lower temperature than water. It may therefore be separated from the water in such liquors as wine or cider by heating them. This is done in a covered vessel with a pipe in a close-fitting cover. As the alcohol rises in vapor, it passes through the pipe which is cooled with ice. The alcoholic vapor condenses to a liquid which is much stronger with alcohol than the liquid put into the covered vessel, and is collected as it drops from the end of the pipe. This process is called distillation. The alcoholic liquors obtained by distillation are brandy, rum, whisky, and gin.

2. Distilled liquors are commonly about one-half alcohol, and therefore have great power to harm the human system, and quickly ruin those who drink them.

By swallowing more in quantity, the beer, wine and cider drinker often gets as much alcohol as the drinker of distilled liquors.[1] The use of the lighter wines, so-called, is a prolific cause of intemperance, for it is the nature of the alcohol in these, as well as in all other alcoholic beverages, to make the drinker want more. In countries where light wines and beer are most used, more of the stronger liquors are also used, and intemperance rapidly increases.

"Our impression is that the lowest, slowest, and most illiterate, most unimpressible, most unimprovable, if not vicious population outside of the great cities, is found in the oldest wine districts, and that the use of the product of vineyards has been the most active cause of this condition of the population; that the increased production and consumption of wine on this coast in the most recent years has diminished the use of neither distilled liquor nor lager-beer, but rather increased the demand for both. We never hear of people who forsake liquor and beer for the sake of wine, but we hear of many who never use an intoxicant till they learn to love wine, and then have abandoned wine for something stronger. In a word, we do not believe that wines reform anybody, and we do believe that they beguile many into drinking habits, and finally into drunkenness, who would never have drank a drop but for wine." — Editor of *The Pacific*.

[1] "All poison habits are progressive. The beer vice is always apt to eventuate in a brandy vice, or else to equalize the difference by a progressive enlargement of the dose of beer." — Felix Oswald, M. D.: *Poison Habit*, page 55.

ILLUSTRATIONS.

1. Examine with a microscope having a magnifying power of at least four hundred diameters, mold from cheese, or other substance, or yeast.

QUESTIONS.

I

1, 2, 3. State the law of death and decay.

4, 5. What is the cause of decay?

6. How do molds and ferments bring about the decay of a substance?

7. Give Pasteur's account of finding mold and ferment germs on grapes.

8. How does mold affect grapes? What part of the grapes do the ferments attack? Do they attack the juice while it is in the whole fruit? What must the ferments have in order to live? Where do they get this oxygen when they are submerged in the expressed grape-juice? What is the result of the breaking up of the sugar by the ferments?

9. Why is there no alcohol in fruit as it grows for our use?

10. What is vinous fermentation? State the law of fermentation.

11. Is alcohol a food or a poison?

II

1. Define a poison.

2. What is a narcotic poison?

3. What kind of an appetite has alcohol the power of creating?

4. What effect has water upon thirst? What is the relation of alcohol to thirst? What is the difference between a natural thirst and the thirst created by an alcoholic liquor? What has every additional quantity of alcohol taken the power to do?

5. What fact shows the connection between the first glass and the drunkard's fate? To what is the drunkard's condition often charged? Is it the weakness of the drinker, or the nature of the drink that leads to drunkenness?

6. What can you say of the rapidity with which the craving for alcohol grows upon its victim? What is the only sure preventive against forming the alcoholic appetite? What is the only remedy for such an appetite when formed? What is the danger in using alcoholic liquors for flavoring food?

7. Why is it a mistake to think the use of the lighter liquors harmless?

8. What can you say of cider drinking in this country?

9. How does cider become alcoholic? How long after cider is pressed does alcohol begin to appear in it? What is the proportion of alcohol in hard cider? How does the use of hard cider often affect the disposition?

10. How is hard cider changed to vinegar? Why is there no alcohol in vinegar? Show how the law of fermentation is carried out in vinous and acetous fermentation?

11. What have science and experience shown concerning the nature of beer? Why is it poisonous?

12. Describe the process that leads to the formation of alcohol in beer?

13. What has beer the power of causing? What are some of the effects beer is likely to have upon the drinker?

III

1. What proportion of alcohol can be produced in a liquid by fermentation? Are any drinks stronger with alcohol than this? How are they made?

2. What proportion of alcohol do distilled liquors contain? May lighter liquors be as injurious as the stronger?

CHAPTER V.

DIGESTION.

I

1. One thing that distinguishes living things from dead matter is that all living things have the power of taking substances into themselves, and making them a part of themselves. That is what we do when we eat and drink.

2. Dead substances may take to themselves new matter and grow in size. The icicle hanging from the eaves does this, and the snow-ball started down a hill-side. A stone may grow by the deposit of material on its surface.

3. But it is easily seen that this kind of growth is very different from that of living things. This kind of growth is called growth by "accretion," — adding to itself a substance like itself. Living things grow by "assimilation," — taking into themselves substances different from themselves and making them a part of themselves.

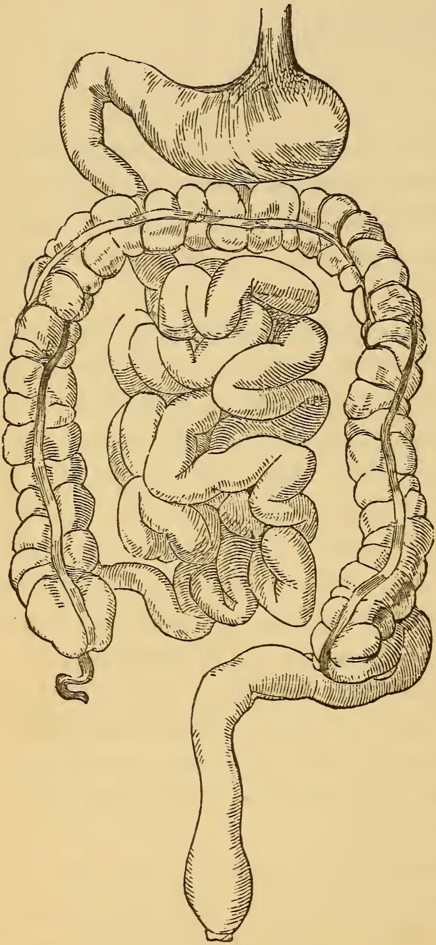
4. Substances are taken into the body through the mouth and nose. Through the nose we take in air only. Through the mouth we take in many different substances, some of them in the solid and some in the liquid state, which we call food and drink.

5. The process of taking in air through the nose or mouth will be treated in another place. In this chapter we will study the parts of the body by which food and

drink are received, and the changes which are made in food and drink before they are taken into the blood.

The Alimentary Canal.

6. The parts which receive and act thus upon food and drink are designated as the "Alimentary Canal and its Appendages."



7. The alimentary canal is a long tube which begins at the lips, and has its outlet at the lower end of the trunk. The appendages to the alimentary canal are the salivary glands, the liver, and the pancreas.

8. The length of the alimentary canal in man is about twenty-seven feet (8.2m.). In a sheep it is eighty or ninety feet (24m. to 27m.). Such a long tube must necessarily be coiled up, as it is in that part of it which constitutes the intestines or bowels.

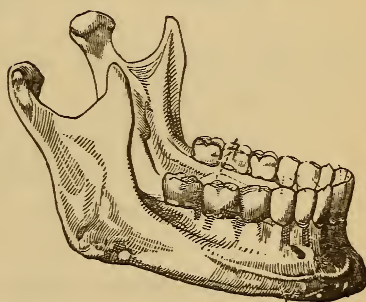
9. This tube is continuous from beginning to end, but different parts of it have different names. The main divisions

are obvious and natural, but certain subdivisions are made which are artificial,—for example, the duodenum in the small intestine. The following table indicates its divisions:—

The Mouth.	The Stomach.
The Throat.	The Small Intestine.
The Gullet.	The Large Intestine.

10. The alimentary canal is not of the same diameter throughout. The stomach is a pouch four or five inches (10 to 13 c. m.) wide. The canal widens here, just as a river in its course sometimes widens into a lake. The small intestine is not more than one inch or one inch and a half wide. The large intestine is twice as wide as the small intestine.

11. The walls of the alimentary canal are thin and flexible. They are made in part of muscle-fibers which run lengthwise and crosswise around the tube. It is by the working of these muscle-fibers, first shortening and then lengthening, that food is churned and kneaded and forced along down.

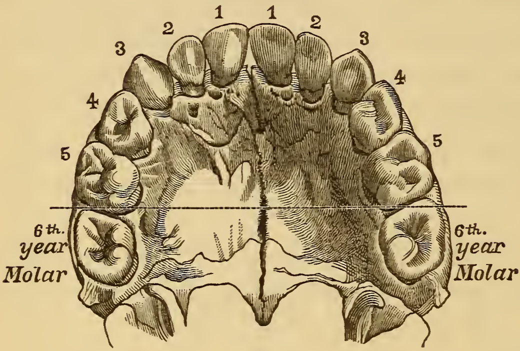


12. The canal has a soft, moist, smooth lining, called the mucous membrane. In the lining are innumerable pores which open into little pits, called glands. These glands make the juices, called digestive juices, which mix with the food and digest it. This is a description of the canal as a whole. Now examine each of its divisions.

The Mouth.

13. The lips are the outer gates and the teeth are the strong inner gates through which the mouth is entered. The teeth begin the work of dividing up and preparing the food for digestion.

An infant has at first no teeth visible, though there are some buried in the gums and ready to come out at the right time. At five or six months' old the front teeth appear and are followed by others at intervals of a month or two. At from two to two and a half years all of the



first set should have appeared. They are twenty in number as follows:

Incisors, or cutting teeth	8
Canines, or long-pointed teeth . .	4
Molars, or grinders, ...	8
TOTAL	20

14. At from five to seven years of age, the front teeth (the incisors) loosen and come out and the other teeth follow one by one, and all are succeeded by the teeth of the second set. The time at which they will appear cannot be precisely stated. Most of the second set have come by fourteen years of age. But there are still four wisdom teeth which do not appear before seventeen years of age, and often not until much later in life.

15. The second set consists of thirty-two teeth, which do not exactly correspond to those of the first set. They are, —

Incisors	8
Canines	4
Bicuspids	8
Molars	12
Total	32

16. The incisor teeth and the canines are adapted to cutting and tearing food. The bicuspids and molars are adapted to grinding it.

17. The teeth are not bones, though they are very much like bone. They differ from bone as ivory differs from bone. A tooth may be divided into three parts — the crown, the neck, and the root. The root may have a number of fangs. The teeth have a cavity in the center which contains the pulp. In the pulp lie the nerve and blood-vessels, which enter by a small hole in the end of the fang. The crown is covered by a thin layer of enamel, which is the hardest substance in the body.

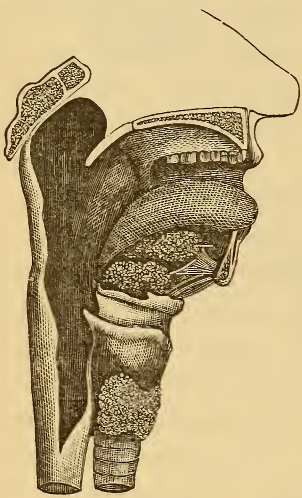
Care of the Teeth.

18. The teeth cut and grind the food and mix it with the saliva. It is very important that this should be thoroughly done. Otherwise the food cannot be well digested. Accordingly, the teeth should be protected and cared for. They may be injured by hot or cold substances; by some medicines; by decomposing food remaining in them; by tobacco. They should be thoroughly brushed at least once a day. They should be examined occasionally by a dentist, and if they are beginning to decay they should be filled. In this way even imperfect teeth may be preserved for a long time.

19. If the teeth are neglected, the mouth will be filled before youth has passed with decaying stumps, which are a source of pain and mortification, and which often poison the blood and impair the health. Such teeth should be removed at once. Fortunately, the dentist can give us something better.

The Tongue.

20. The tongue has two offices: First, in articulation; second, in moving the food. It is itself made of muscle, the fibers of which run longitudinally, transversely, and vertically. It is also acted upon by muscles descending from above, ascending from below, extending from the lower jaw-bone backward, and from behind forward. It is capable, therefore, of changing its shape, and of moving with great rapidity and precision in every direction.



Both in articulation and mastication, it has very delicate work to do. It is aided in this by a most delicate sense of touch. In no other part is this sense so fine and accurate. The tongue shifts and turns the mass of food, placing it deftly between the teeth, and finally passes it back to the throat.

The Throat.—The Gullet.

21. The throat is a portion of the alimentary canal, about four inches (10 c.m.) long. Both the nose and the mouth open into it. The windpipe and the gullet lead out of it below.

22. The gullet lies just behind the windpipe, and is nine inches (22.8 c. m.) long. It opens into the stomach. Its walls are soft, and are always pressed close together, except when something is passing down. The lower end of the gullet is nearly opposite the lower end of the breast-bone.

The Stomach.

23. The stomach is a pouch about a foot (30 c. m.) long, which lies under the heart, separated from it by the diaphragm. The diaphragm is a thin membrane, and when the stomach is swollen with gas, as happens in the case of indigestion, it presses the diaphragm up, and crowds the heart. This causes uncomfortable and sometimes distressing sensations in the heart. A fancied heart disease is often only dyspepsia.

24. In an infant the stomach lies almost in the direction of the backbone, — up and down. It is very easy for an infant to throw up the contents of the stomach. In a grown person the stomach lies more nearly across the backbone. It is joined to the gullet, as the foot is joined to the leg, nearly at a right angle. Therefore it is more difficult for a grown person to vomit.

25. Like the rest of the alimentary canal, the stomach has muscle-fibers in its wall. These muscle-fibers are in three layers, which run in different directions. One layer surrounds the stomach, another layer runs lengthwise. Another runs in an oblique direction. By the contraction of these layers, the stomach can squeeze and knead its contents thoroughly.

26. The lining of the stomach is pinkish in color, and has in it innumerable pores opening into the little pits, called glands, already referred to. These glands

manufacture the gastric juice. Some of them are single tubes and others are branched.

The Pylorus.

27. At the lower end of the stomach the small intestine begins. At this point there is a ring of muscle surrounding the tube which can keep it closed. This ring is called the pylorus, which means the "keeper of the gate." Its duty is to let no food pass down which is not properly mixed with the saliva and gastric juice. It is a very obstinate gate-keeper, and sometimes holds undigested matter in the stomach for twenty-four hours or more until it is finally thrown up. Sometimes the keeper gets tired of resisting, and the offending substances pass down, causing perhaps pain in the bowels. The small intestine is twenty feet (6 m.) long, and the large intestine, which is the lower part of the alimentary canal, is five feet (1.5 m.) long. The upper part of the small intestine for about ten inches (25 c.m.) is called the duodenum. Here an important part of the work of digestion is done. In the lining of the intestines, small and large, are found millions of pores similar to those in the stomach. They also manufacture a fluid which aids digestion.

II

The Salivary Glands.

1. Before describing the salivary glands, it will be well to define a gland. There are many organs of the body which we call glands. The liver and spleen and kidneys are glands. The little pits in the lining of the stomach, just described, are glands. We have sweat-

glands in the skin and tear-glands in the eye. These differ in structure and size and appearance very much. In one thing they are all alike. All except the spleen have for their work to manufacture some fluid to be used in the body, or to be thrown out of the body. The spleen and a few other glands have for their work to make some changes in the blood and lymph. We can say, therefore, that a gland is an organ whose work it is to manufacture or modify the fluids of the body.

2. The salivary glands manufacture saliva. There are three pairs of them.

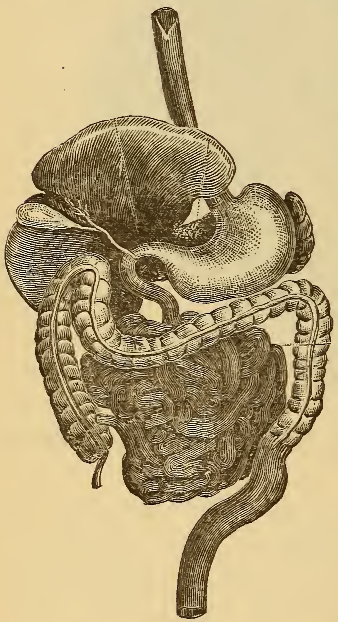
(*a*) *The parotid glands.* These lie under the ear. In mumps they swell and are painful. Their outlet is a tube two and a half inches (6$^{c.m.}$) long, which runs straight forward in the cheek, and opens into the mouth opposite the second molar tooth.

(*b*) *The submaxillary glands.* These lie just under the floor of the mouth, inside the jaw-bone. Their outlet

is under the tongue close to the middle line. The fluid can sometimes be seen to spurt from them.

(*c*) *The sublingual glands.* These are the smallest of the three pairs, and lie farthest forward. They are beneath the floor of the mouth, and pour their fluid into it by several small openings.

3. The salivary glands are called compound glands. They each consist of a great many tubes, with little sacs on the ends of them, like grapes on a stem. These little tubes empty out into larger tubes, until finally all are joined in one large tube, which is like the main stem of a bunch of grapes. Blood-vessels pass between the tubes and surround the sacs. The saliva is made in the sacs from the blood, and flows out through the tubes.



4. The saliva is a mixed fluid from the three pairs of glands. The fluid from the parotid glands is thin and watery. That of the other glands is thicker, and makes a slippery coating over the food in the mouth.

The Liver.—Gall Bladder.

5. The liver is the largest gland in the body. It weighs about four pounds, and lies behind the lower ribs on the right side, and extending over the pit of the stomach in front to the left side.

6. The gall-bladder is closely connected with the under surface of the liver. It is a sac about three inches ($8^{c.m.}$) long, shaped like a slender pear. The duct of the liver is a tube about as large as a goose-quill, which opens into the upper part of the small intestines. The duct of the gall-bladder joins the duct of the liver. The gall-bladder is a receptacle for bile, when it is not needed in the intestines.

7. We infer from the size of the liver that it must do a very important work. It makes almost a quart of bile daily. Bile is a yellow fluid which becomes green if it remains in the stomach or bowels long. It has a very bad taste. It helps to digest food.

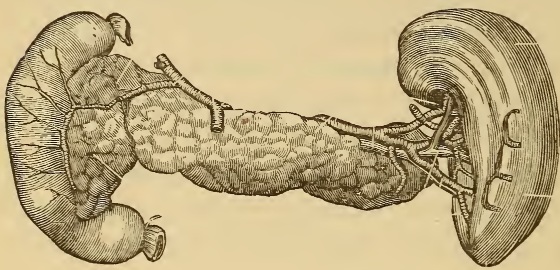
8. Sometimes the duct of the liver becomes stopped. Then the bile as it forms in the liver is prevented from flowing out. The blood-vessels take it up, and carry it all through the system. It is deposited in the tissues, and gives the skin the yellow color which is seen in jaundice. The bile which is thus retained is a poison to the whole system. The liver in making bile purifies the blood.

9. The liver also makes and stores up glycogen. This is a substance like starch in its chemical composition. It is made chiefly from the sugars and starches in our food. Vegetables make and lay up a great deal of starch. Animals make very little. The most of what animals make is stored up in the liver as glycogen.

The Pancreas.

10. The pancreas, the sweet-bread in calves, is a long, slender gland which lies behind the stomach across the backbone. It is a good deal like the salivary glands

in its construction. It is a compound gland, made up of numerous small sacs and tubes uniting until they form one large tube or duct, which empties into the upper part of the small intestines at the same opening which admits the bile. The pancreas, although one of the smallest glands, makes daily a pint and three-quarters (800 grms.) of a very active fluid, the pancreatic juice. It does a considerable part of the work of digestion.



III

Digestion.

1. The alimentary canal corresponds to the kitchen in a hotel, where food is received from the street, and is prepared before it is distributed to the various rooms as it is demanded. So before the food can become part of the blood, and be carried to the hungry tissues, it must undergo a change. That alteration takes place in the alimentary canal, and is called digestion.

2. The food is acted upon in two ways in digestion. (1) Mechanically, by the cutting and grinding of the teeth and by the kneading of the stomach and intestines. (2) Chemically, by the action of the digestive fluids.

3. In the mouth food is cut and ground into bits, and is thoroughly mixed with saliva. This prepares it

to be acted on by the juices of the stomach. Food which is swallowed in lumps is slowly and with difficulty penetrated by the gastric juice. Hence the great importance of eating slowly, and thoroughly masticating the food.

4. The saliva, besides softening portions of the food, and covering them with a slippery coat, which makes it easy to swallow them, also acts directly on the starchy substances, changing them into sugar. Starch cannot pass through the wall of the alimentary canal, even should it be dissolved. Sugar can. Hence all starchy matters are changed into sugar, and this change is begun by the saliva.

5. The average amount of saliva which gets into the mouth in twenty-four hours is at least a pint and a half. (.8 L.) It flows freely when we are eating. Even the thought of food causes the mouth to water. When we are not eating, it serves to keep the mouth moist, and so makes articulation possible. Fear sometimes stops the action of the salivary glands, and so the young orator, it may be, finds his "tongue cleaving to the roof of his mouth" when he makes a speech.

6. The soft and smooth mass of food is pressed back by the tongue into the throat, and the muscles there contract around it in such a way as to send it into the gullet, and the gullet, contracting above it, forces it into the stomach, as we might strip fluid out of a flexible tube by drawing it between our finger and thumb.

7. When the mouthful of food arrives in the stomach, the lining of that organ is flushed by the blood flowing into it, and the little glands begin to pour out the gastric juice. It stands in drops at the mouths of these

glands, as perspiration stands on the surface of the skin. The drops succeed each other rapidly as more food is introduced.

8. We will suppose that the mouthful of food consists of meat, bread, and butter. Of these only the meat and a small portion of the bread are really digested in the stomach. The butter is scarcely changed. The meat is liquified, and made into a substance called peptone, which can easily pass through the walls of the alimentary canal, as pure meat juice cannot.

9. If the gastric juice is not sufficient in quantity, or if it is poor in quality, digestion does not go on well and distress may result.

10. After food has remained in the stomach a varying length of time—for some substances half an hour, for others several hours—that which is not fully digested passes into the duodenum. It has become a thick liquid like gruel, gray in color, and is called chyme.

11. In the duodenum the chyme meets the bile and the pancreatic juice. The starchy matters, represented in this case by bread, were acted on a little by the saliva, but not at all by the gastric juice. The pancreatic juice mixes with them and digests them, by changing them to sugar. The fat represented by butter has not been changed in the stomach. The bile and the pancreatic juice digest that by making an emulsion of it.

12. An emulsion is a thorough mixture of fat or oil with some fluid. We cannot make an emulsion with pure water. The oil may be mixed for a moment, but it will soon rise to the top, while the water settles below it. But the pancreatic juice makes a perfect emulsion. The oil stays mixed, and its particles are very finely

divided. When oil is in this condition, it is capable of passing through the walls of the alimentary canal.

13. Meat and other animal foods are digested chiefly in the stomach. Bread and other starchy foods and the fats are digested chiefly in the duodenum. The little glands in the wall of the intestine below the duodenum give out a fluid called the intestinal juice. This aids in completing the process of digestion, and keeps the mass of food moist.

14. There is always some portion of our food that is indigestible,—the woody parts of vegetables and the gristle in meats, for example. Such substances pass through the alimentary canal without essential change.

IV

Effects of Alcohol.

1. If a few drops of clear alcohol are taken into the mouth, they make a burning sensation. A little larger quantity gives pain. We reject it at once, as we would corrosive acids or other substances capable of injuring the mucous membrane.

2. Alcohol is a chemical agent of great power. When brought into contact with animal tissues, it extracts the water which they contain and coagulates the albumen. In the living tissue, by its irritant action, it produces important changes.

3. The pepsin of the gastric juice is precipitated by alcohol, so that fluid loses its digestive power as long as the alcohol remains in the stomach.

4. These facts can be shown by experiment in the laboratory, and have been confirmed by observation of human subjects.

5. Dr. Beaumont, in those studies of the stomach of Saint-Martin, which gave us much of our present knowledge of that organ, made careful and repeated observations of the effect of alcohol upon it.[1] He discovered that after the frequent use of alcoholic drinks for several days, the lining of the stomach looked inflamed; patches of ulceration appeared; the gastric juice became ropy and tinged with blood. The ulceration and change in the secretion increased as he continued the use of spirits. "But," says Dr. Beaumont, "these morbid changes are seldom indicated by any ordinary symptoms or particular sensations complained of, unless when in considerable excess." Much damage may be done to the stomach while the drinker is unaware of it.

6. Alcohol hinders digestion in still another way. Through its power of extracting water, it is capable of hardening the food that should be dissolved in the stomach, and thus renders it less easy of digestion.

7. The erroneous belief that wine, beer, or cider, aids digestion has often led to the formation of the alcoholic appetite, and to injury of the stomach that has resulted in dyspepsia.

8. It is the belief of physicians that dyspepsia is a common result of indulgence in alcoholic beverages.[2]

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[1] Saint-Martin was a French-Canadian, who had an opening through his side into his stomach, in consequence of a gunshot wound. Dr. Beaumont took the man into his service, and for eight years made studies, at different times, of the inside of the stomach and the processes going on there.

[2] Dr. B. W. Richardson says, that it is one of the most definite of facts, that persons who indulge even in what is called the moderate use of alcohol suffer often from dyspepsia from this cause alone.

9. The train of effects in the stomach, caused by the use of alcoholic liquors, is congestion, ulceration, thickening and ultimately contraction of the mucous membrane, with the obliteration of many of the glands which supply the digestive juice.

10. But while digestion and the stomach itself are being ruined by strong drink, they are becoming more and more dependent upon it. The want of appetite for food and the gnawing or burning at the pit of the stomach are intolerable. The drinker craves more alcohol. This gives a temporary relief, but increases the trouble.

11. The effect of alcohol on the intestines is less commonly observed than its effect on the stomach. For much of it passes out before reaching the lower part of the alimentary canal. But it is similar. The same irritant action produces the same congestion, and the same permanent changes in the lining membranes.

12. From the stomach alcohol is carried in the blood directly to the liver, where it filters through the liver-tissues and is the cause of injurious changes. It leads to an excessive overgrowth of connective tissue between the liver-cells and surrounding the blood-vessels. This new growth of connective tissue gradually contracts, and crowds the blood-vessels within it, hindering the natural flow of blood, and also compresses the enclosed liver substance. The cells, thus compressed, shrink, and cause the liver to contract in places, leaving little projecting knobs in other spots where the cells are not yet injured. Such a liver is sometimes called a "hob-nailed liver" from its appearance, or "gin-drinker's liver" from its well-known cause. This condition of the liver interferes with the proper preparation of bile and other work

of the liver essential to health, and is not brought about by hard drinking only, but may be caused by the continuous excitement kept up by habitual "tippling."[1]

V

Hygiene of Digestion.

1. Good digestion is one of the chief foundations of our health, and an important condition of happiness. Unless the work of the alimentary canal is properly done neither body nor mind can work well. Dyspepsia means bad digestion. It is often caused by not taking proper care of the stomach. Some people have by nature strong stomachs, which will bear much neglect and ill-usage. Others have weak stomachs, and these must be treated well.

2. To maintain good digestion several rules should be observed, —

(*a*) We should not eat fast. We cannot chew our food properly if we do, and the lumps which pass into the stomach are not easily digested by it.

(*b*) We should not eat too much. If the stomach is too full it cannot knead the food, and the digestive juices may not be sufficient for the mass. That part which is not digested will decompose, producing acidity and a pressure of gas.

(*c*) Fried food is indigestible, because the fat which is cooked into it coats over the particles, and protects them against the action of the digestive juices.

(*d*) Great fatigue or great excitement hinder digestion.

[1] Dr. George Harley: *London Lancet*, March 3, 1888.

Food taken under these circumstances may lie entirely unchanged in the stomach until it is thrown off from it.

(*e*) The mind should be at rest during a meal. The man who has an after-dinner speech to make is liable to have indigestion. Hard thinking or studying should be discontinued at the table, and cheerful conversation and light thought should take their place.

(*f*) Ice-water chills the stomach, and should not be taken during a meal. It is best to abstain from all drink while eating. Too much liquid dilutes and weakens the gastric juice.

(*g*) Observe regular hours for meals. Take two or three or four meals a day according to circumstances; but let them be at fixed times. Irregular eating tires and weakens the stomach.

ILLUSTRATIONS.

1. Pupils can study the teeth in their own mouths and those of their companions. The alimentary canal of a bird, or some other small animal, will give a general idea of this tube. To show how fats are prepared for digestion, make an emulsion of fat with the white of an egg, or a weak solution of gum acacia, and compare it with a mixture of fat in water.

QUESTIONS.

I

1. Name a property of living things that distinguishes them from not-living things.

2. Can not-living things grow?

3. What is growth by accretion? What is growth by assimilation?

4, 5. How are substances taken into the body?

6, 7. What is the alimentary canal? What are its appendages?

8. How long is the alimentary canal?

9. What are its divisions?

10. What is the width of the alimentary canal?

11. What is the use of the muscle-fibers in the wall of the alimentary canal?

12. Describe the lining of the alimentary canal.

13. Has a newborn infant any teeth? How many teeth in the first set, and how are they named?

14. When do the second set come?

15. State the number and the names of the second teeth.

16. What purposes do the different kinds of teeth serve?

17. Are the teeth true bones? Describe the different parts of a tooth.

18. How may the teeth be injured? How should they be cared for?

19. What is the result of neglect of the teeth?

20. What is the work of the tongue? How is it fitted for this work?

21. Describe the throat, and the openings into and out from it.

22. Describe the gullet.

23. What is the stomach? How may indigestion seem to be heart disease?

24. What is the position of the stomach in an adult? in an infant?

25. What muscle-fibers are in the walls of the stomach?

26. Describe the lining of the stomach?

27. What is the pylorus? What is its work? How long is the small intestine? the large intestine? What is the duodenum? What work is done in the intestines?

II

1. What is a "gland?" Name some of the glands and their work.

2. Name the salivary glands, and tell where they are situated.

3. What is the structure of the salivary glands?

4. Describe the saliva.

5. Give the size and location of the liver.

6. Describe the gall-bladder and its work.
7. What is the work of the liver?
8. What happens if the bile-duct is stopped?
9. What is glycogen?
10. Describe the pancreas. How much fluid does it secrete daily?

III

1. What is digestion?
2. In what two ways is food acted on in digestion?
3. Why is it important to chew food thoroughly?
4. What is the work of saliva?
5. Does saliva flow when we are not eating? How much is poured out in twenty-four hours?
6. Describe the act of swallowing.
7. What takes place in the stomach when the food arrives there?
8. What parts of the food are digested in the stomach?
9. What happens if the gastric juice is poor or scanty?
10. What is chyme?
11. Where are starchy matters digested? Where is fat digested? What fluids digest starch and fats?
12. What is an emulsion?

13, 14. Where is meat chiefly digested? bread? butter?

IV

1. What is the sensation caused by alcohol in the mouth?
2. What is the chemical action of alcohol?

3, 4. What effect has alcohol on gastric juice?

5. What effects of alcohol did Dr. Beaumont observe in the stomach of Saint-Martin?

6, 7, 8. Does alcohol ever cause dyspepsia?

9. Describe its effect on the stomach.
10. Does the drinker learn to dislike the drink that is injuring him?

11, 12. What is the effect of alcohol on the intestines? on the liver?

V

1. How may dyspepsia be acquired?
2. Give some rules for avoiding dyspepsia?

CHAPTER VI.

ABSORPTION.—THE BLOOD.—THE LYMPHATICS.

I

1. In the preceding chapter we studied the first part of the process of Assimilation, namely, digestion. This is the preparing of food in the alimentary canal to be taken into the blood.

2. The alimentary canal is a closed tube. It has been likened to a kitchen, where food is dressed and cooked. But a kitchen has a door and halls leading from it, by which food may be carried to all parts of the house. The alimentary canal has no openings through its walls, except ducts of the salivary glands, the liver and pancreas. How, then, does digested food pass through?

3. It soaks through. If you fill a glass bottle with water and put a stopper in, not a particle of water will come to the outside. It is water-tight. But if you fill a leathern-bag with water, drops will be seen on the outside surface. In this respect the alimentary canal is like a leathern-bag.

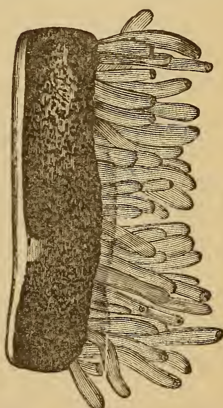
4. In the wall of the alimentary canal are innumerable very small blood-vessels, with walls thinner than tissue-paper. They are there for the purpose of taking up the liquid food, as it soaks out of the alimentary canal. It soaks into them, just as water will soak through a kid-glove and wet your fingers inside.

5. In these little blood-vessels the blood is constantly moving. So that as the liquid food enters, it is carried away directly, and the blood-vessel is ready for more. The farmer lays pipes made of tile under ground in a wet field, and the water in the soil soaks into them and flows off. The water may be said to be "absorbed" by the tile-pipes. So digested food is absorbed by the little blood-vessels in the wall of the alimentary canal.

Absorption.

6. Absorption may take place in any part of the alimentary canal. Take a piece of sugar in your mouth and let it dissolve. A part of it will be absorbed. It will pass into the little blood-vessels under the lining of the mouth.

7. There is not much absorption in the throat or gullet, because our food passes through them so rapidly. Besides, only a small portion of food is yet ready to be absorbed. In the stomach a part of the animal food is absorbed as fast as it is digested. Starchy and fatty foods are not absorbed there, because they have to be prepared farther down.



8. It is in the small intestines that most of the food is absorbed. Here the starches and fats are digested, starch being turned into sugar and fat being mixed in an emulsion. There is in the small intestine a special apparatus for absorption which will now be described.

9. If the lining of the small intestine be examined

with a magnifying glass, it presents a velvety appearance. This is because it is like velvet, in being covered with short, thread-like prominences standing closely together as in the nap of cloth. There are thirty or forty of them in a square millimeter. They are called *villi*.

10. If one of these *villi* be studied under a microscope, it is found to contain a net-work of small blood-vessels and a tube which begins here and is connected with a set of vessels, called lymphatics. These *villi* are bathed in the liquid food, as the rootlets of a plant are bathed in the water of the soil, and they drink up fluid as the rootlets do. Nearly all the fat is taken up by the *villi*, and enters into the tube which is connected with the lymphatic system.

11. When the food has reached the lower end of the intestine, most of the liquid digested portions have been absorbed into the blood-vessels and lymphatics.

II

The Blood.

1. The first step in assimilation is digestion; the second step is absorption. The digested fluid has now become a part of the blood. That which was a few hours before meat, fruit, and bread is now blood.

2. The blood is a red fluid, saltish in taste, warm when it comes from the living animal, soon thickening to form a clot.

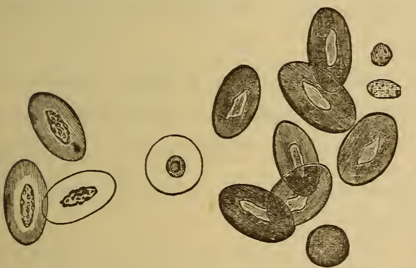
The Corpuscles.

3. If blood be examined with a microscope it is seen to consist of a clear and transparent liquid, with numerous little globules floating in it. These globules give it

a red color. They constitute about half of the blood, and are commonly called the blood corpuscles. Most of them are of an amber color, when seen one at a time, but when gathered in a mass they are red. About one in four to six hundred is white.

4. The white corpuscles are spherical in shape. The red corpuscles are shaped like two saucers, placed back to back. They are thinner at the center than at the circumference.

5. All animals with a backbone (vertebrates) have red blood corpuscles. But the shape of these is different in different classes. In birds, reptiles, and fishes the corpuscles are oval. In the class mammals, to which man belongs, they are round and flattened. It is easy to determine, by examining a drop of blood with a microscope, whether it came from a mammal or not.



6. We can determine from such an examination whether a drop of blood came from a human being, or one of the lower members of the order of mammals. For all of our domestic animals, except fowls, are mammals, and have round corpuscles. The corpuscles of each species of animals are almost precisely uniform in size; and no two species have corpuscles of the same size. There are only a few mammals whose corpuscles are as large as man's. The huge elephant and the whale have corpuscles a little larger, and so have three or four other mammals. But

dogs, cats, sheep, oxen, horses, — in short, all the animals that are in this country associated with man have smaller corpuscles.

7. The red corpuscles in man measure 1.3200 of an inch (7.9 mmm.) in diameter. Those of the dog, the nearest in size to mankind in our domestic animals, are 1.3500 (7.25 mmm.).

8. Ordinarily, therefore, an expert microscopist could determine whether a blood-stain were from human blood or not. For even though the stain is dried, it can be carefully soaked out, so that its corpuscles can be restored to their natural size. But where human life is at stake, testimony depending on such nice measurement should be received with caution.

9. The red and white corpuscles go rolling along in the blood stream, and when they are crowded in a very small blood-vessel, they yield and change their shape. But they are elastic, and resume their natural shape as soon as they are out of the crowd.

10. The red corpuscles have, for their special work, to carry oxygen from the lungs to every part of the body. Oxygen is the King of the Elements, and these are his royal chariots. When they leave the lungs they are full of oxygen, and are bright-scarlet. When they come back to the lungs they have given up much of their oxygen, and are purplish-red. It is the presence or absence of oxygen that makes this change in color.

11. People in good health have an abundance of red corpuscles, and these take up oxygen, which colors them scarlet. The blood in the blood-vessels of the skin gives the skin its rosy hue.

12. People in poor health often have too few red cor-

puscles, and the blood has little color, and the cheeks and even the lips are pale.

13. In many cases the very best remedy is fresh air and exercise. Take in oxygen, and make it fly through the arteries and veins by active work or play, and your cheeks will soon take on color. But sometimes medical help and advice are needed.

The Plasma.

14. The liquid part of the blood is called the plasma. It contains nutritive matter formed from the digested food. The digested food is changed as it is absorbed. We find, for example, very little fat in the blood, though the animal is eating much fat and is growing fat. The elements of the fat are there however.

15. We find very little sugar in the blood. Although a person may be eating a great deal of it, and although all the starchy foods are changed into sugar in digestion, it becomes a part of the blood when it is absorbed and is no longer sugar.

16. Eight-tenths of the blood is water. The various mineral substances—phosphates, sulphates, and chlorides—that we take in our food are found in the blood. In its course through the body it is constantly changing its constitution, like a river that takes up matter here and deposits it there.

17. It is from the very smallest of the blood-vessels—the capillaries—that the nutritive matter gained from the food passes out to the tissues. The blood feeds upon the digested food, and the tissues feed upon the nutritive matter in the blood. This nutritive matter passes out of the blood-vessels in the same way that it passes

into them. It soaks out. It bathes the surrounding particles of flesh, or nerve, or skin, or whatever they may be. They take it into themselves, and their strength is renewed. This is the final step in the process of assimilation. It is the tissues, the little particles of the body, that assimilate the food finally, and so the life of the whole body is maintained.

18. We have then,—

DIGESTION.	CIRCULATION.
ABSORPTION.	TRANSUDATION.

ASSIMILATION.

The four preliminary steps being fairly included with the fifth under the general term, assimilation.

19. The tissues are built up by the food assimilated. At the same time they are continually breaking down. These two acts go on together. As new matter is brought in, the old waste matter must be given out. Life in the tissues of the body is accompanied by a kind of combustion. The food is the fuel, and the waste matters are the dust and ashes. The latter must be carried away, or the fire will not burn. So one great work of the blood is to carry away waste matter from the tissues. The waste matter gets into the blood as food does. It soaks in at the same time that nutritive matter soaks out from the capillaries. And it is swept along to be finally cast out of the body by the lungs, the skin, or the kidneys.

Coagulation of the Blood.

20. Blood flows from a cut freely at first. This naturally causes some alarm in the lookers-on. For we know that "the blood is the life," and when we see the

crimson stream we feel that the life is ebbing away. Many turn faint and sick at the sight; and probably every serious cut would be fatal, but for a remarkable provision which Nature has made to guard against such a result.

21. Fresh blood, after being exposed to the air for a few seconds, begins to grow thick. In ten minutes it has changed from a fluid to a jelly. This is called coagulation.

22. When a cut has been received, the blood which at first is running fast soon thickens, and its flow is thus checked. The little blood-vessels become plugged-up and the whole cut is often filled with this jelly-like clot. This will usually take place even if the cut is left entirely alone, if it is not too serious. But blood coagulates more readily when it is flowing slowly than when it is flowing fast. So we help nature by putting a bandage over the wound, or pressing it with our fingers. Of course when very large blood-vessels are cut, they must be immediately closed by pressure, or by tying a thread around them.

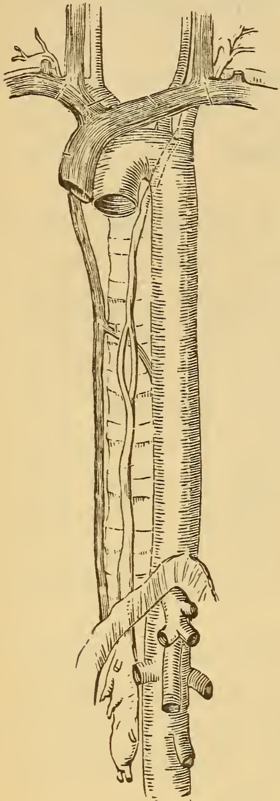
23. This must be done by some one who is skillful. But any one can press the lips of a wound together. While waiting for a physician, a handkerchief can be tied about the hurt above the wound. Sometimes it is needful to tie one below the wound also.

III

The Lymphatics.

1. There is a set of vessels found in close connection with the blood-vessels, called the lymphatics. These

begin as the finest of spaces and channels in the tissues. Hair-like tubes, with very thin walls, lead from these spaces and channels. These tubes unite to make larger tubes. These again unite, and so on until they end in two main tubes, each half the size of a lead pencil. These main tubes are called the thoracic duct and the right lymphatic duct. They empty into the great veins at the root of the neck.

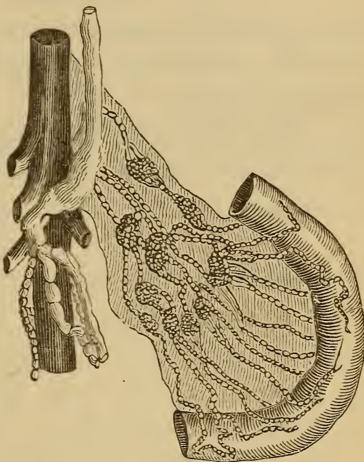


2. These tubes carry their contents only in one direction,—namely, towards the heart, differing in this respect from the blood-vessels. They are found just under the skin, and in the deeper parts of the body.

3. They are like drain-pipes. Their work is to take up the fluid which has soaked out of the small blood-vessels and which bathes the tissues, and carry it away to pour it finally into the blood again.

4. The tubes that are found associated with the blood-vessels in the *villi*, in the lining of the small intestine, are lymphatics. They take up fat, and during digestion are milky in appearance. Hence they are called lacteals (*lac*, milk). When there is no fat in the intestine they look like other lymphatics, and are doing the same kind of work.

5. In the course of the lymphatic vessels are many little kernels, some as large as a grain of wheat, some as large as a bean, through which the vessels appear to pass. Those which lie underneath the skin can be felt in some places. In the neck and elsewhere they sometimes become inflamed and swell to a great size. They are called lymphatic glands.



6. The fluid, which is called lymph, passes through the lymphatic vessels. It is colorless, and is much like the plasma of the blood in composition. In dropsy the lymphatics are unable to do their work, and the tissues are filled almost to bursting with this fluid.

IV

Pure and Impure Blood.

1. Pure blood is blood that contains the ingredients which properly belong to it, and no others.

2. The blood of one who eats too much will be overloaded with matter from the food, which cannot be used by the tissues, and it thus becomes impure.

3. The blood of an indolent person, who takes no exercise, will be likely to become impure. It will not have oxygen enough. Moving slowly all the time, it will not get rid of its waste matters fast enough, and will be likely to be overloaded with food matters.

4. The blood of one who eats too rich or highly seasoned food will be impure.

5. The blood of one who spends much of his time in bad air will be impure.

6. The blood of one who uses tobacco contains the poison nicotine.

7. The blood of one who uses intoxicating drinks contains the poison alcohol.

V

Effects of Narcotics on the Blood and Tissues.

1. Alcohol passes from the stomach into the blood. Now we have seen how alcohol hardens or coagulates the albumen of the food in the stomach, and hinders its digestion. It affects in the same way the albumen in the blood, and thus makes the blood much poorer in quality for feeding all the tissues of the body, which depend upon it for their nourishment. In sufficient quantities alcohol injures the blood corpuscles, and thus lessens their power of absorbing oxygen. In this way it hinders the processes by which the blood is purified. The blood of a drinking man is often found, upon examination with the microscope, to be loaded with fat as well as with other impurities. Since the blood goes to all parts of the body, carrying whatever is in it wherever it goes, these impurities are carried also, causing disease. The alcohol does not become a part of the blood, as the food does, but is carried by the blood unchanged to all parts of the system, and is the same poisonous substance that it was when first taken into the stomach. It injures not only the blood but every tissue to which the blood carries it.

ILLUSTRATIONS.

1. Illustrate absorption with an earthen flower-pot, or a brick, or a glove-finger.

2. To show blood corpuscles wind a handkerchief tightly around a finger, and with a slight prick draw a drop of blood. Take this off on a glass slide, and with the edge of another slide or a knife-back, spread the blood so thin that it shows little color. Examine with a magnifying power of three or four hundred diameters.

3. If blood can be obtained from the butcher, the clot can be shown and the serum which separates from it.

QUESTIONS.

I

1. What is the first step in the process of assimilation?

2. Is there any passage way from the alimentary canal to the blood-vessels?

3. How does digested food get out of the alimentary canal?

4, 5. What is absorption?

6, 7, 8. In what part of the alimentary canal does absorption take place?

9. What are the *villi?*

10, 11. Describe the *villi* and their work?

II

1. What is the second step in the process of assimilation?

2. Describe the blood.

3. What are the corpuscles of the blood? What two kinds are there?

4. What is the shape of each kind?

5. What division of the animal kingdom has red blood corpuscles? Is the shape of these the same in all animals?

6. Is the size of the red corpuscle the same in all animals?

7. What is the size of man's red corpuscles? of the dogs?

8. How can an expert determine to what animal a drop of blood belongs?

9. How do the corpuscles behave when crowded?

10. What is the work of the red corpuscles?

11, 12. How does the color of the face indicate the state of health?

13. What is a good remedy for poor blood?

14, 15. What is the plasma of the blood? Do we find much fat or sugar in the blood? 16. What proportion of the blood is water? What mineral substances are found in the blood?

17. How does nutritive matter finally reach the tissues?

18. What five processes are included under the general term assimilation?

19. How is life in the tissues like a combustion? What has the blood to do besides bringing nourishment to the tissues?

20, 21. What is the coagulation of the blood? How is it a safeguard?

22, 23. How may coagulation in a wound be aided.

III

1. Describe the lymphatics.

2. What difference between the course of the lymphatics and of the blood-vessels?

3. What is the work of the lymphatics?

4. Why are some of them called lacteals?

5. What are the lymphatic glands?

5. What is lymph? Why does the body swell in dropsy?

IV

1. What is pure blood?

2, 3, 4, 5, 6, 7. Name six causes of impurity of the blood.

V

1. What effect has alcohol on digested food? on the blood corpuscles? Does alcohol become part of the blood? How does it make the blood impure?

CHAPTER VII.

THE HEART AND BLOOD-VESSELS.—THE CIRCULATION.

I

1. There are in the body of a grown person six or eight quarts of blood. It does not fill the spaces in the tissues, as water fills the spaces in a sponge, but is confined to tubes called blood-vessels. Some of these are large and many are small. The small ones are so small that they are called capillaries (*capilla*, a hair), and they are smaller than hairs. They cannot be seen without a magnifying glass. The capillaries penetrate every particle of living tissue, and they are so numerous and so near together that you cannot put a needle-point in the flesh without piercing some of them.

2. A leaf is sometimes treated with chemicals, which eat out all the soft, green parts and leave only the ribs and the connecting fibers between them,—the frame-work. The result is exquisitely delicate, and is called a skeleton leaf. If the body of an animal could be treated in a similar way with something that would eat out everything except the blood-vessels, we should still have a perfect figure, every organ being represented by a network of extreme fineness.

3. The heart and the blood-vessels are the circulatory apparatus. The blood is the medium by which nour-

ishment gets to the tissues, and by which waste matter from the tissues reaches the organs that throw it out. It may be looked on as the channel of communication between different portions of the body, by which they are enabled to work together, as railroads or rivers and canals are the means of communication between different parts of the same country.

4. The body, with its parts and organs, may be compared to a country with its provinces or states. If the steam-cars stop running and the canals and rivers are closed, much of the business of the country must be at a stand-still. So when the blood stops flowing, the life of the body and its organs must cease.

Fainting.

5. The more delicate and sensitive the organ, the more dependent it is on a permanent supply of blood. The brain, for example, is said to have about one-fifth part of the blood in the body. If, for an instant, the heart stops beating, or beats very feebly, the brain is affected. The person becomes unconscious and falls. This is a fainting fit. The action of the brain stops, because it is not getting its customary supply of blood.

6. When, therefore, any one faints, the proper thing to do is, —

(*a*) Give him fresh air. This will stimulate the heart. The worst thing to do is to crowd about him, and shut off the air.

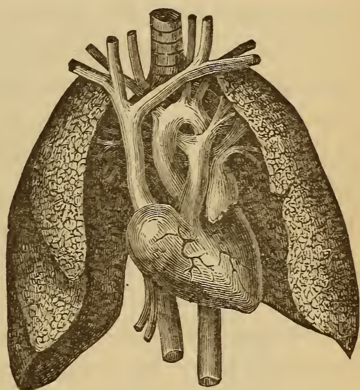
(*b*) Lay him on his back. In the horizontal position the blood flows to the head much more readily than in the upright position. Do not lift him up.

(*c*) If these measures are not sufficient, sprinkle a

little cold water on his face, tickle his nose with a fine feather, or hold a bottle of smelling salts to it. The heart can be roused to action by adopting methods like these. As soon as it is beating with its ordinary strength and frequency, the brain resumes its control.

The Heart.

7. The heart is made of muscle, and is as large as the fist. It is shaped like a pear, and lies in the chest, more of it on the left than on the right side. The point, or apex, is between the fifth and sixth ribs, and the base, which looks upward and to the right, extends as high as the third rib. It lies upon the diaphragm, and is held up by the great blood-vessels which are attached to it.



8. The heart is incased in a loose sac, called the pericardium. This has a very smooth lining, which is always slightly moist, so that as the heart moves there is no friction.

9. The heart is hollow, and its interior is divided by a partition extending from base to apex into a right and left half which have no direct connection with each other. These halves are sometimes spoken of as the right and left heart, as though they were entirely separate.

10. Each half is again divided into two chambers, an auricle and a ventricle. The auricle is at the broad end, and has walls not more than one-twelfth of an inch

($2^{mm.}$) in thickness. The ventricle extends to the apex, and has thicker walls. The walls of the right ventricle are one-sixth of an inch ($4^{mm.}$) in thickness. The walls of the left ventricle are half an inch ($12^{mm.}$) in thickness. The capacity of these chambers is about the same. Each will hold from three to six ounces (85 to 170 $^{c.c.}$) of fluid.

11. There is no direct communication between the right and left sides of the heart, but each auricle communicates with the ventricle, on the same side, by a round opening an inch ($25^{mm.}$) in diameter. These openings are closed by valves: that in the right side being the tricuspid, or three-pointed; that in the left side the mitral (like a miter). These valves are flaps made of the lining membrane of the heart. They are thin, but strong. They open like folding-doors into the ventricle when the blood is passing through. If it flows back, they close as folding-doors close when a crowd is pushing against them in the wrong direction. Fine, tough cords are attached to their edges and to the sides of the cavity of the ventricle, which keeps them from opening back into the auricle.

The Blood-Vessels.

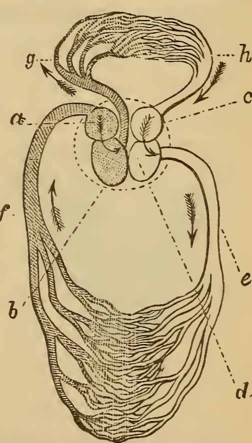
12. The blood-vessels leave the heart and extend to every part of the body, and then return to the heart. They differ in size in the structure of their walls, and in the part they have to perform in the circulation.

13. From the right ventricle one large artery curves off, the pulmonary artery. This soon divides into two great branches, one of which goes to the right lung, the other to the left lung. As these branches enter the lung they divide again and again, as a limb of a tree

divides into branches and twigs, these growing smaller as they divide.

14. At the same time their coats grow thinner. The smallest divisions are not more than one-three-thousandth of an inch ($8^{mmm.}$) in diameter, and their walls are thinner than the thinnest tissue-paper. They are called capillaries. The capillaries are short but innumerable, and make a close net-work around the air-cells of the lung. Many capillaries combine to form a vein. Small veins unite to form larger ones, until all the veins in each lung have joined in one or two large veins, called pulmonary veins, which empty into the left auricle of the heart. We started from the right ventricle, followed the blood-vessels through the lungs, and return to the left auricle.

15. From the left ventricle the blood is driven into the aorta, a great artery, which runs down beside the backbone. From the aorta branches are given off to the head, and to the upper limbs and to the trunk. At the lower part of the backbone the aorta divides into large branches that supply the lower limbs.



16. If we follow any of these branches we shall find them dividing again and again, just as in the lungs, until we come to the capillaries, and then to the veins, which all finally join in two great veins, called respectively the superior and inferior *vena cava*. These empty into the right auricle.

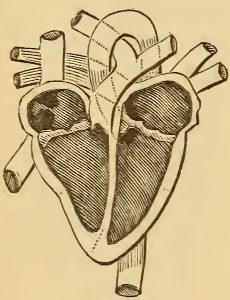
17. We have therefore two sets of vessels, one of which goes through the lungs and constitutes what is called the

pulmonary circulation, while the other goes through the rest of the body and constitutes the general circulation. These, however, are not separate, but connected through the openings between the auricles and ventricles.

Work of the Heart.

18. The heart beats from sixty-five to seventy-five times a minute in a grown person. This beat which can be heard with the ear on the chest, and can be seen over the point of the heart, is caused by a sudden contraction of its walls. The heart is made of muscle-fibers, and these have a fixed habit of contracting forcibly so many times in a minute. The blood in its cavities is in that way driven out at each beat, as water is forced through a rubber syringe by squeezing its bulb.

19. A rubber syringe has little metal valves, which prevent the water from pouring backward when the bulb is squeezed. The valves of the heart, the tricuspid and mitral, answer the same purpose.



20. Follow the course of the blood through the heart. Remember that the heart is a double organ, the right and left side each propelling its own stream. The blood enters the right auricle through the *vena cava superior* and the *vena cava inferior*. It enters the left auricle at the same time through the pulmonary veins. At this time the muscle is relaxed, and the cavities are wide open to receive the blood flowing freely through them. Suddenly the auricles contract with a

quick movement and throw the blood through the openings, which lead to the ventricles. The valves are wide open. Next the ventricles contract. The blood pushes the valves up, and they come together so that nothing can pass back into the auricles. The stream must go forward, and it enters from the right ventricle, the pulmonary artery, from the left ventricle, the aorta. At the commencement of each of these great vessels are valves (the semi-lunar valves), somewhat like those in the heart, which close after the blood has passed through, and prevent its flowing back into the ventricle during the period of relaxation, which directly follows its contraction.

21. This is the process which is repeated sixty-five to seventy-five times a minute during life. This is the force that keeps the blood flowing through arteries and capillaries and veins throughout the body. The circulation depends mainly on the heart.

22. The heart has in itself the power of contracting and relaxing in this way. A frog's heart will contract for some time after it is taken out of the body. The action of the heart is regulated in the living body by nerves.

23. The sounds of the heart are two short, quick sounds, one rapidly succeeding the other. They may be heard by listening over the apex. The first sound is caused by the sudden closing of the valves of the heart. The second, which is shorter and higher pitched, is caused by the closing of the semi-lunar valves in the great blood-vessels.

24. The heart does not stop by night or by day. Arms and legs become exhausted, and must have long rest;

but the heart gets its rest in the little interval between its contractions, and that appears to be sufficient for it Indeed, if all these short periods of repose are added together, they will amount to ten or twelve hours in twenty-four. The heart never feels tired if we are well. It has been estimated that the work done by the heart in twenty-four hours is enough to raise three hundred tons weight one foot from the ground.

25. The beating of a healthy heart is perfectly regular, but in some disorders it becomes irregular and intermittent. It beats now fast and now slow, and often skips a beat. "Smoker's heart," caused by the use of tobacco, acts in this way.

26. Palpitation of the heart is a rapid, hard beating which is very distressing. It is an indication of weakness, but not necessarily of any heart disease. It is often caused by indigestion.

27. Sometimes the lining of the heart and the great arteries become inflamed. The valves, which are folds of this lining, become thickened and hardened. They no longer close accurately and when they open they, by their size and roughness, obstruct the flow of the blood. When the valves of a pump become stiff and worn-out, the pump is of little use. So a heart affected in this way works badly, and is liable to stop working suddenly. This is heart disease.

II

Work of the Blood-Vessels.

1. The vessels that carry blood away from the heart are called arteries. Those which carry blood back to the heart are veins. The small, thin, walled vessels which fill

the tissues and connect the arteries with the veins are the capillaries.

2. The arteries are very elastic. When blood is thrown into the aorta, it stretches and then contracts, so helping to hurry the stream along.

The Pulse.

3. It is this elasticity of the arterial walls that makes the pulse. The pulse is a beating of an artery which can be felt by the finger-end laid upon it. Sometimes the pulse can be seen, as in the temple or the neck. It can be felt wherever an artery lies near the surface of the body. The artery on the thumb side of the wrist is the one commonly sought for by the physician, because it is easy to find.

4. From the pulse the physician learns how many times the heart is beating each minute. The usual number has been estimated as follows: —

At birth	130 to 140
First year	115 to 130
Second year	100 to 115
Third year	90 to 100
Tenth year	85 to 90
Fourteenth year	80 to 85
Adult life	65 to 75

5. The number of heart-beats varies at different times in the day. It is greater in the morning and after eating. It is less in sleep and in the recumbent posture. It is increased by excitement and by heat. Each person has a standard number of beats per minute, and it is well for each to find out what it is, that the physician who

is called when sickness comes may know how much the heart is departing from its proper action.

6. The physician likewise learns from the pulse how strong the heart-beat is, how full the arteries are, and whether their walls are hard or soft. All these things inform the skillful observer as to the state of the system and the remedies required.

7. Near the heart the pulse is very strong and quick. Farther away from the heart the pulse is less marked. If an artery be cut near the heart, the blood comes in spurts at every heart-beat. If an artery some distance away from the heart be cut, the stream is more even. From the capillaries and veins it is steady, with no spurting. In these vessels there is no pulse. If the blood flows from a wound in jets which keep time with the heart-beat, it is certain that an artery has been cut. If it flows in a continuous stream, it is from a vein.

The Capillaries.

8. The capillaries are the most important of the blood-vessels. The work of the arteries is to carry blood to the capillaries, and the work of the veins is to carry blood from the capillaries. It is the capillaries, with their thin walls, that permit nourishment from the blood to soak out and bathe the tissues, and the capillaries take up carbon dioxide and other waste matters from the tissues. The capillaries are very small, but they are so numerous that if they were all put together to make one large tube, this would be three hundred times as wide as the great arteries (aorta and pulmonary) which come from the heart.

9. Since the blood stream widens so much in the capillaries, it must flow more slowly in them, as a river flows more slowly when it widens out than when it is rushing between narrow banks. In the aorta the blood flows at the rate of ten inches ($254^{mm.}$) in a second. In the capillaries it flows at the rate of one-fiftieth ($.5^{mm.}$) of an inch in a second.

The Veins.

10. The capillaries are continued by the veins. These are more numerous than the arteries. Consequently they are not so full, and the blood flows more slowly in them. Their walls are not so thick nor so elastic as those of the arteries, but they are very strong.

11. There are certain parts in the veins that we do not find in the arteries, namely, the valves. These valves are flaps of the lining membrane, similar to those already described, which stand out like little pockets. These pockets open in the direction in which the blood is flowing, and lie flat against the wall of the vessel. If any thing makes the current of blood set back, the pockets fill and bulge out and stop the backward flow. Valves are not needed in the arteries except at their very beginning, because the heart keeps forcing the current along. But in the veins they are useful.

12. Experiments on animals have shown that it takes about twenty seconds for the blood to go from the heart through arteries and capillaries and veins back to the heart again.

Regulation of the Circulation.

13. Both arteries and veins have muscle-fibers in their walls which run crosswise and surround the tube. When

these fibers contract it makes the tube smaller, and thus presses out a part of the blood in it. When they expand they make the tube larger, and more blood flows through them. Nerves in these muscles make them contract and expand, thus regulating their size and the amount of blood they can retain. This is a very important provision. The heart also has its controlling nerves, one of which, called the inhibitory nerve, has a restraining influence upon the heart's action. If this nerve is cut the heart begins at once to beat rapidly and tumultuously.

14. It is not sufficient that the blood should be carried through the body in an even stream, as water flows through the city supply-pipes, always taking as much to one place as to another. There must be in the animal body some way of regulating the supply. When any organ is acting vigorously, it needs more blood than it does when it is at rest. If the brain, for example, would go to sleep, the supply of blood to it must be for the time diminished. While it continues to flow in a full stream we cannot sleep. An abundance of blood in any part stimulates that part. If the muscles are actively exercising, they need a larger supply of blood, and it must be drawn off from other parts. We feel disinclined to hard exercise immediately after a hearty meal, because then the blood is in the walls of the stomach and is turned off in part from the muscles.

15. While therefore every part of the body must have blood all the time, no part wants the same amount all the time. And the supply to any part is regulated by the contraction or expansion of the arteries in that region. The arteries are controlled by the nervous system.

16. When the body is inactive the circulation becomes

sluggish. Then the tissues are not supplied with fresh oxygen as fast as they need it, and the waste matter is not promptly removed. This makes the mind dull and the body liable to disease.

17. Physical exercise is necessary to keep body and mind in good condition. Playing ball or tennis, boating, riding, and other out-of-door sports, keep the circulation active.

III

Effects of Alcohol on the Heart and Blood-Vessels.

1. The beating of the heart is very quickly affected by any disturbance in the nerves which should control its beats. Alcohol, by its power to deaden these nerves, is a serious heart disturber. A small quantity taken into the blood quickly paralyzes the inhibitory nerve, whose office, as we have seen, is to hold the heart in check. The heart at once begins to beat faster, just as it would if this nerve were entirely cut off from all connection with the heart.

2. The amount of work which the heart does in health is almost incredible. To increase that amount, by making the heart beat faster than it should, is to put unnecessary and extra strain upon an organ whose healthy condition is essential to life. A couple of glasses of wine, by paralyzing the inhibitory nerve of the heart, will sometimes increase its beats from three to four strokes per minute. Calculating the weight of blood which the heart lifts at each beat at about six ounces, four extra beats every minute would cause it to lift ninety extra pounds of blood in an hour, which would amount to over a ton in the course of twenty-four hours.

3. When a person sits or lies down, the heart does not need to lift so much blood as when he is standing or walking. It does not therefore beat so frequently, and thus gains some additional time for rest. This is one of Nature's wise provisions to give the heart rest while other parts of the body are resting. But the man who goes to bed with a glass of beer or wine circulating through his blood paralyzes, to a greater or less extent, the inhibitory nerve of his heart, and this causes that organ to keep beating at a rapid rate when it should be beating at a slow one. In this way he deprives his heart of the rest it needs. It is not strange, therefore, that the moderate drinker frequently has "heart trouble."

4. We have seen that the blood of the drinker is often overcharged with fat. The heart is very liable to be a place of deposit for such extra fat, especially if it is at the same time weakened by overwork. The fat may collect in such quantities upon the outside as to press upon the muscles of which the heart is composed, and in time cause injurious changes in them; or the fat in the blood may be lodged between the layers of muscle, and crowd upon these until they become weakened and changed to fat themselves. Sometimes alcohol causes the muscular walls of the heart to thicken and encroach upon the cavities until they cannot hold their due amount of blood; or it may cause them to grow thin. Then the cavities of the heart become too large. It may cause deposits of fatty or earthy substances in the muscular walls of the heart, making them liable to rupture from any unusual strain. A like dangerous change takes place very often in the arteries of the habitual drinker. Instead of being soft and elastic,

the walls of the arteries become hard and brittle, and very liable to burst at any moment. Cases of sudden death from this cause in intemperate people are frequently reported by physicians, who have made examinations after death, and found striking illustrations of these changes in the coats of the arteries, caused by indulgence in alcoholic drinks.[1]

5. As we have seen, there are nerves in the walls of the blood-vessels that cause them to contract and expand. Alcohol quickly paralyzes these nerves, and that lets the walls of the blood-vessels stretch too much, and more than the proper amount of blood rushes into them. The face of the drinker becomes flushed soon after he has swallowed his wine or beer. This is because the nerves in the walls of the blood-vessels in his face have been paralyzed by alcohol and the vessels have expanded, and too much blood has rushed to his face, making it red. This paralyzing action of alcohol on the nerves in the walls of the blood-vessels, letting too much blood go to places where it should not, is the secret of much harm which alcohol does to the body.

6. The circulation of the right amount of blood through the different organs of the body is essential to health. Alcohol, by causing the blood-vessels to unduly expand, disturbs the proper circulation of the blood.

ILLUSTRATIONS.

1. Show a heart and blood-vessels from the butcher's. Pour water through it, and show the working of the valves. Cut it open and point out the cavities and their openings.

[1] Rupture of the blood-vessels, causing sudden death, is not always due to alcoholic drinks.

2. Pupils can observe in themselves and each other the sounds and the movements of the heart, and can find and count the pulse.

QUESTIONS.

I

1. How much blood is there in the body? What are the capillaries?
2. Where are the capillaries found?
3. What is the circulatory apparatus? What is the use of the blood?
4. Illustrate the work of the blood.
5. What is a fainting fit?
6. What should be done for a person who has fainted?
7. Describe the heart.
8. Describe the pericardium.
9. What is meant by the terms right heart and left heart?
10. What are the auricles of the heart? the ventricles? What is the capacity of each?
11. Is there communication between the chambers of the heart? Describe the valves of the heart.
12. What is the course of the blood-vessels?
13. Follow the pulmonary artery and its branches.
14. To what vessels does the pulmonary artery lead? What vessels carry the blood from the pulmonary artery back to the heart?

15, 16. Starting in the aorta follow the blood in its course until it has returned to the heart.

17. Explain how we may be said to have a double circulation. Are the two parts of the heart entirely distinct?

18, 19. How many times in a minute does the heart beat? Describe the action of the heart.

20. Follow the course of the blood through the heart and describe the action of each part.
21. What is the power that keeps up the circulation?
22. How is the action of the heart regulated?
23. What are the sounds of the heart? the cause of each?

24. Does the heart get any rest? How is the work it does measured?

25. What is a "smoker's heart"?

26. What is palpitation of the heart?

27. What is the effect of inflammation of the heart's lining?

II

1. What are arteries? veins? capillaries?

2, 3. What is the pulse? Where may the pulse be felt?

4. What is the usual rate of the pulse at different periods of life?

5. What natural variation in the rate of the heart-beats?

6. What does the physician learn by feeling the pulse?

7. When blood flows from a wound, how can we tell what kind of a vessel it comes from?

8. What is the work of the capillaries? What is the combined diameter of the capillaries?

9. How fast does the blood flow in the aorta? in the capillaries?

10, 11. Describe the veins.

12. How long does it take for blood to make the circuit of the vessels, and return to the heart?

13. How is the circulation regulated?

14, 15. Why is it necessary that the supply of blood should be regulated?

16. What effect has bodily inactivity on the circulation?

17. What effects have out-of-door sports on the circulation?

III

1. What effect has alcohol on the nerves which control the heart?

2. How much extra work by the heart would four extra beats per minute signify ?

3. How does the heart get its rest? How does alcohol deprive it of a portion of its rest?

4. What effect has alcohol on the walls of the heart and of the blood-vessels?

5, 6. How does alcohol interfere with the proper distribution of the blood?

CHAPTER VIII.

RESPIRATION.—AIR.

I

1. Besides food and drink, air is required by the body for the maintenance of its life. The need for air is more pressing than the need for food or drink. It is possible to live for many days without drinking, and for weeks without eating, but no one can live for five minutes without breathing. While, therefore, we must exert ourselves to procure food, air is supplied to us without limit.

2. Air is a mixture of gases as follows: in one hundred parts of pure air,—

Nitrogen about	79
Oxygen "	20.96
Carbon dioxide	.04
TOTAL	100.00

Air contains also some vapour of water. We can see the water in our breath on a cold day. It gathers in drops on the window-pane in a room full of people.

3. The act of breathing is as constant as the beating of the heart. If we suspect a motionless figure to be dead, we watch for the breathing; for this ceases only with life, though at times it may be scarcely perceptible.

4. With each breath we take in twenty cubic inches (327 c.c.) of air. Its composition has already been given. When this air is breathed out, its composition has been

changed. Of the one hundred parts taken in, there is returned in expiration,—

Nitrogen about	79
Oxygen "	16
Carbonic dioxide	4
TOTAL	99

5. Comparing this table with the preceding, it appears that the amount of nitrogen is unchanged. Almost five of the twenty-one parts of oxygen are lost,—that is, they are taken up by the body. The carbon dioxide is increased one hundred-fold. There is also an increase in the amount of watery vapor. The act of breathing then gains oxygen for the body from the air, and gives carbon dioxide from the body to the air.

6. The expired air is about one per cent. less in volume than the inspired air at the same temperature. In other words, the increase in carbon dioxide does not quite equal the loss in oxygen, by volume. In weight, however, this expired air exceeds the inspired air. We lose weight with every breath. Not man alone, but all animals, take oxygen from the air and give carbon dioxide to the air in breathing. Neither man nor other animals take more than a little nitrogen from the air, or give it to the air. The use of the nitrogen seems to be to dilute the oxygen. The diluted oxygen is better adapted to breathing than pure oxygen would be.

7. Carbon dioxide is for animals a waste substance. They cast it out, but do not take it in. For plants it is food. Animals take in oxygen and give out carbon dioxide; plants take in carbon dioxide and give out oxygen. Thus a balance is maintained.

8. In cities where there is great crowding together of people and lower animals, and little vegetation, the air contains more carbon dioxide than it does in the country. Fires and lights also consume oxygen and make carbon dioxide. But air is always in motion, and the forests and the ocean keep it pure.

9. Oxygen is the most active and powerful of all the chemical elements. It is also the most abundant, as it constitutes about half of the material world. Its activity is so great that it has been called the King of the Elements and the Life-Giver.

II

The Respiratory Apparatus.

1. Let us now examine the respiratory apparatus. This apparatus differs in different animals. The object of breathing is the same in all, namely, to take oxygen into the body and give up carbon dioxide from the body. In the lower kinds of animal life, which have no organs, but are simply masses of jelly-like matter, the oxygen penetrates from the surface through the whole mass and the carbon dioxide passes off from the surface. But in higher animals oxygen is first introduced into the blood, and by the circulation of the blood is carried to all parts of the body. In the same way the carbon dioxide is carried from all parts of the body to that part which receives the oxygen, and there it is cast out.

2. In the frog and some other animals the skin is a breathing organ. As long as the skin is kept moist oxygen passes through it to the blood-vessels, and is exchanged for carbon dioxide. In fishes the blood gets its

oxygen in the organs that we call the gills. These are thin plates of membrane full of blood-vessels which lie in an opening of the neck communicating with the mouth. Now water contains a certain amount of air dissolved in it, and the oxygen of this air enters the blood of the fish in its gills. A fish dies in the air because its gills get dry, and that stops its breathing.

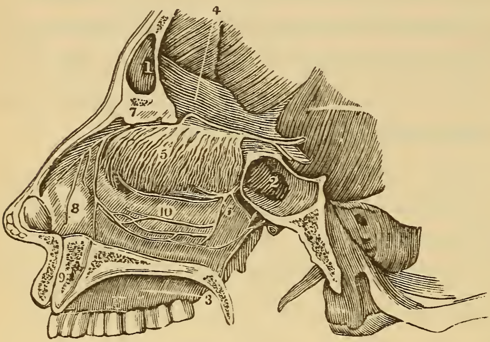
3. In men and other vertebrates, Nature adopts a different plan. The skin would not do for a breathing organ in a land animal, because it is not sufficiently moist. Oxygen and carbon dioxide do not readily pass through the membranes of the body when they are dry. For the same reason, the blood could not be brought to the surface as in the gills of the fish. In an animal living in the air, the membranes, through which the exchange of gases between the air and the blood takes place, must be enclosed in a cavity of the body. Only in this way can they be kept moist enough to serve their purpose.

4. The lungs are situated in the chest, and the air is brought to them through tubes. The lungs are masses of very small air-sacs, at the ends of the air-tubes. These masses are penetrated by the blood-vessels which closely surround every sac.

The Respiratory Passages.

5. The respiratory passages begin at the nose. This organ is divided into two parts by a central partition. The nostrils open into two narrow passages extending back about three inches (76 mm.), and ending at the upper part of the throat. The nose serves not only for breathing but likewise for smelling; the sense of smell being situated in the upper part of the nasal passage.

6. We can breathe through the mouth, and at times it is necessary to do so. But this is not the natural way.



The nasal cavities have moist walls close together, and the air passing through them is warmed and softened. The air taken in through the mouth dries the throat, and in cold weather chills the lungs. Unless there is some obstruction in the nose, the habit should be maintained of closing the mouth while not speaking. It is a safeguard against colds and sore throats to keep the mouth closed, when coming out of a warm room into the air, on a cold and damp evening.

7. Snoring is the result of sleeping with the mouth open. The soft palate hangs relaxed between the currents of air, like a sail in the wind, and rattles in a similar fashion.

The Throat.

8. The throat is a cavity four inches (10 c.m.) long, lying behind the nose and mouth. It has seven openings into and out from it,—

(*a*) The two posterior openings of the nasal cavities.

(*b*) The two eustachian tubes from the ear. These connect the cavities of the ear, which lie behind the drum-head, with the throat. They are as necessary as

the hole in the side of a drum. When they become closed, as they sometimes do in catarrh, deafness results. This is relieved often suddenly, and with a crackling sound when the tube is opened, so that the air can pass through. The act of swallowing opens the tube. In blowing the nose, we can feel a pressure in the ears made by the air forced through these tubes.

(*c*) The mouth.

(*d*) The windpipe.

(*e*) The gullet.

The last two openings are at the bottom of the throat. The windpipe lies in front, and is usually open. The gullet is behind it, and is usually closed.

The Larynx.

9. The larynx, or voice-box, is on the top of the windpipe. It is made of cartilage, lined with mucous membrane. It forms a prominence in the throat which is called Adam's apple. It is divided into two chambers by a pair of curtains, whose edges are the vocal chords.

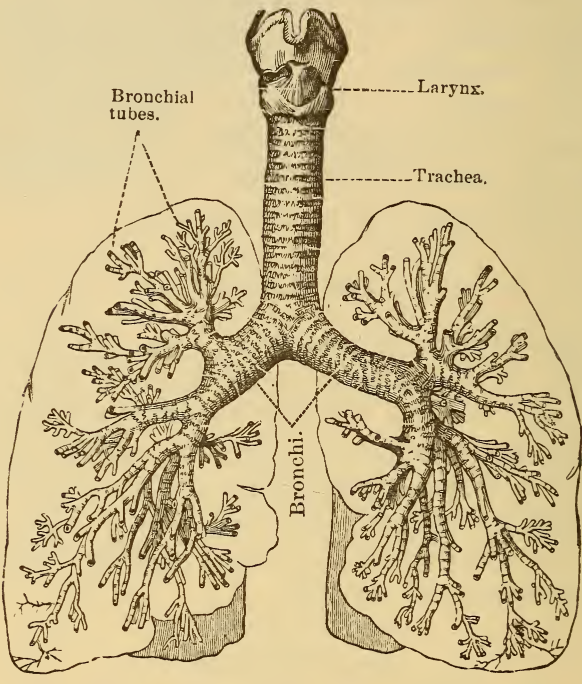
10. The slit between the vocal chords is the glottis. It may be closed entirely or widely opened. When it is closed, breathing is stopped.

The Windpipe.

11. The windpipe (*trachea*) is four inches ($10^{c.\,m.}$) long. Most of the tubes in the body have soft walls, which fall together when the tube is empty. The gullet is such a tube; but the windpipe has stiff walls that keep it always open. Its walls are made stiff by a series of sixteen to twenty rings, made of cartilage. These rings

are not complete, but are like a horseshoe in shape. They leave a space which is filled in with membrane.

12. The reason for this construction is easily seen. The tube must be kept wide open, so that air can pass through. Food and blood, or other fluids, can force their way through soft tubes; but it is necessary that the air



should have a perfectly free course, so the windpipe and the bronchial tubes are made hard.

13. But if the rings of cartilage completely surrounded the tube, they would press on the gullet which is behind it. Besides, it could not enlarge or contract at all. Because the back of the wall of the windpipe is soft,

the gullet is not compressed, and the windpipe can be narrowed, bringing the ends of the cartilage together. This is done in speaking and singing.

The Bronchi.

14. The windpipe divides in the chest into two branches called bronchi, one of which goes to the right lung and the other to the left. These bronchi have also rings of cartilage in their walls.

The Bronchial Tubes.

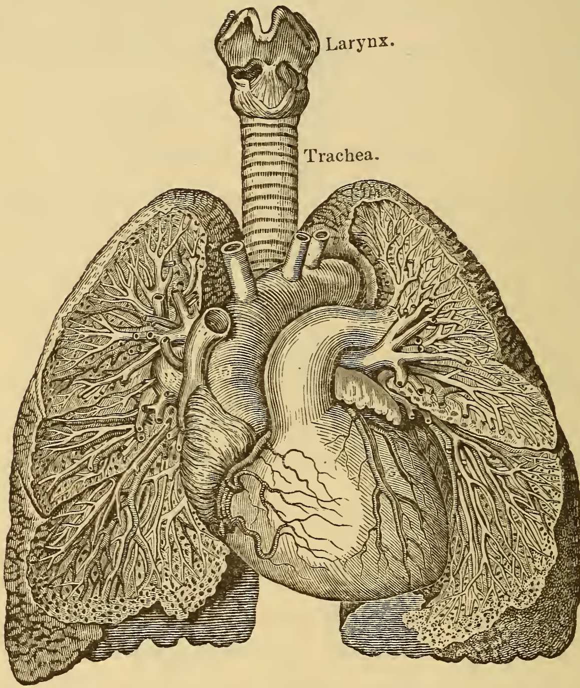
15. Arriving at the lungs, the bronchi divide into the bronchial tubes, and these go throughout the lungs, constantly giving off branches. The smallest branches end in the lobules (bunches of air-sacs), which are not more than one-fiftieth of an inch (.5 $^{mm.}$) wide.

16. We may compare the windpipe to the trunk of a tree. The bronchi are two great branches, and the lobules containing the air-sacs are the leaves on the ends of the smallest twigs.

Blood-Vessels of the Lungs.

17. Having traced the passages by which the air is introduced, let us examine the blood-vessels of the lungs. The pulmonary artery comes from the right ventricle of the heart. It soon divides into two branches, which enter the lungs with the bronchi. These branches divide and subdivide as the bronchial tubes do. On reaching the lobules and air-sacs, the capillary blood-vessels form a close net-work around them. From these net-works small veins come off, which keep uniting and

forming larger and larger veins as they pass out, until finally one or two large veins emerge from each lung at the point where the arteries and bronchi go in. All these tubes, lying close together, make the "root" of the lung. The pulmonary veins empty into the left auricle of the heart.



18. If we picture the air-passages as a tree, we can picture the blood-vessels as a vine following the branches of the tree out to the ends of the twigs.

19. Besides the blood-vessels and air-tubes, there are in the lungs fibers, many of them elastic, which hold these parts together.

The Pleura.

20. Each lung is covered by a bag made of a very delicate membrane, called the pleura. The lung is not contained in the bag; but the bag, which is closed, is wrapped about it, — one layer adhering closely to the lung, the other to the inside of the chest. The layers are kept moist and smooth and play on each other, so that in the movements of the lungs there is no friction. The pleura performs the same service for the lung that the pericardium does for the heart.

21. The pleura is sensitive, and when it becomes inflamed is very painful. This condition is called pleurisy.

22. The lungs are perfectly adapted to the purpose of bringing the blood and the air into close contact. Oxygen can readily pass through the wall of the air-sac and the wall of the capillary, both of which are thinner than the thinnest tissue-paper, and enter the blood. Carbon dioxide can as readily pass in the other direction.

III

Breathing.

1. But the apparatus, thus far described, is not sufficient. The air-passages are open and air will enter. But it is necessary that the air in the lungs should be constantly renewed; that the old air should pass out, and the fresh air should go in, fifteen or twenty times in a minute. This is effected by breathing.

2. Fifteen or twenty times in a minute, — twenty-five thousand times in a day, — we repeat this act while life continues. It is a voluntary act, and it is also an in-

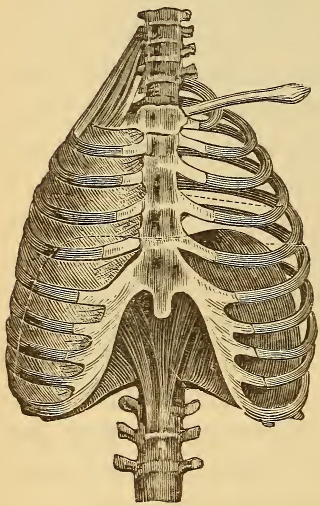
voluntary act. We can breathe at will or we can hold our breath for a time, but not long. The demand of the body for air soon overcomes us, and we must breathe whether we will or not.

3. Breathing must go on during sleep and other temporary unconsciousness, and so it is made, like the beating of the heart, independent of the will.

4. To understand the act of breathing, we must examine the chest and its muscles.

The Chest.

5. The chest is a bony cage which contains the heart and the lungs. It has the backbone behind, the breastbone in front, and the ribs completing the circle. It has an opening at the top between the muscles of the neck. Its floor is formed by the diaphragm.



6. The diaphragm is a sheet of muscle and tendon attached to the backbone and the breastbone, and to the edges of the lower ribs. It stretches across the cavity of the body, and divides the chest from the abdomen.

7. On the outside of the chest are the respiratory muscles attached to the ribs and breast-bone.

8. We have here a cage or box which is remarkable

in this respect. It has walls of bone which afford protection to the delicate organs which it contains, and yet it is capable of expansion and contraction. Thus the strength which belongs to hard material, like bone, is combined with the flexibility of a softer structure.

9. Watch a person breathing, and you see what? You see the chest rise and enlarge, and then fall and contract. It does not enlarge because the air enters it. The opposite is true. The air enters because the chest enlarges. It is the principle of the bellows. Take hold of the handles and open the bellows, and the air rushes in. Close it, and the air is forced out. Air is always pressing in every direction, and will enter every vacant space which presents itself.

10. The chest is expanded in the following way: The muscular diaphragm, which is not flat but arches up into the chest, contracts and descends, thus making the chest deeper. At the same time the external muscles act and draw the ribs and breast-bone, upward and outward. The lungs which are elastic, and are held to the chest-wall by the pleura, expand as the chest expands, and every little air-sac in them expands. The air pours into the cavity, thus enlarged, through the respiratory passages. In an instant the muscles are relaxed. The diaphragm, forced up by the contents of the abdomen, arches into the chest and lessens its size. The ribs settle down and the chest narrows, and the elastic lungs, which have been stretched, contract, and the air is gently pressed out. In ordinary, quiet breathing, only certain small muscles of the chest are brought into play. But in hard breathing, as in asthma or croup, the larger muscles act with great force.

IV

Changes in the Blood.

1. The blood that goes to the lungs from the right ventricle of the heart is purplish-red in color. The blood that comes from the lungs to the left auricle of the heart is scarlet in color. The scarlet blood, after reaching the left auricle, passes to the left ventricle and thence into the arteries that carry it through the body. It retains its scarlet color until it enters the capillaries in the tissues. There it turns purplish-red, and so continues during its course through the veins to the right auricle of the heart, thence into the right ventricle, and so on to the capillaries of the lungs, where it again becomes scarlet.

2. In the lungs oxygen enters the blood, and gives it the scarlet color. In the tissues oxygen is given up by the blood, and it loses its scarlet color. If a little dark blood from the veins be shaken up in the air, it will take up oxygen and turn scarlet.

3. It has been found that the red corpuscles are the carriers of oxygen. They may be called the chariots in which the King of the Elements rides to his destination in the body.

4. The carbon dioxide is taken up into the capillaries chiefly by the fluid portion of the blood. It is given off from the capillaries of the lungs.

V

Ventilation.

1. To be healthful the air must be pure,—that is, it must contain the proper amount of oxygen and carbon dioxide, and it must be free from all injurious gases.

2. Air that has been once breathed is impure, because it has lost oxygen and gained carbon dioxide and other impurities. Fires and lights make air impure. Nature preserves the purity of the air, as a whole, by keeping it in motion. The polluted air that hangs over a city is swept away, and replaced by winds from the great uninhabited spaces. Nature ventilates for us out-of-doors on a grand scale.

3. But we live most of the time indoors. We shut out the winds, because we must keep warm. To keep warm and have pure air to breathe is often very difficult, but we must have it in order to keep well. We should either open our windows and doors for a minute every little while, to let the bad air out and the pure air in, or we should have our rooms so arranged that pure air will keep coming in all the time, and bad air going out. One way of doing this, when nothing better is provided, is to fit a board a few inches wide underneath the lower sash of the window. This makes an opening between the two sashes across the middle of the window, where pure air may be continually coming in without causing a draft.

4. In addition to this, there should be some way of escape for the bad air. For this purpose doors and windows should be opened frequently. While this is being done in a "living room," delicate persons and those liable to take cold may be protected by extra wraps, or they may go into another room.

5. When a school-room is being thus aired the pupils should spend the time in vigorous exercise, to avoid taking cold. The heat should be turned on before and during such an airing, that the cold air coming in may

be quickly warmed. Unless care is taken to prevent it the air in school-rooms, halls, parlors, work-shops, or any closed place occupied by a number of people, soon becomes loaded with impurities. Every person in such a place is spoiling half a barrel of air with every breath he sends out. Pupils are often dull and have headaches, and audiences become inattentive from being poisoned with bad air.

6. As soon as a school or audience is dismissed, all the windows and doors should be thrown wide open until the impure air is driven out.

7. A person occupying a room alone should not remain in it long without a change of air. No person should sleep all night in a closed room, breathing over and over the air that is made more poisonous with every breath.

8. Scientific men are constantly studying the question, How shall we secure good ventilation?—and no perfect method has been devised.

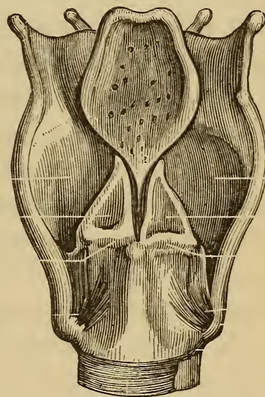
9. The nose is a good tester of the air of a room. When it smells close, it is impure. But after some time spent in a close room, the nose becomes accustomed to the bad air and is a less faithful monitor. A person coming from out-of-doors quickly detects impurities of the air, which may not be noticed by those inside.

10. While the construction of school-rooms and other public buildings must be left to engineers and architects, those who have charge of such buildings must exercise constant vigilance to introduce fresh air. In our homes the same care must be taken. Sleeping-rooms should be thoroughly aired during the day, and for persons in good health an open window at night is desirable.

VI

The Voice.

1. The voice-box is situated in the top of the windpipe. Sound is made as the breath is going out, and not commonly as it is passing in. In this box the air passes through a slit between the vocal chords. The vocal chords can be made tight or loose by little muscles connected with them; and the opening between them (glottis) can be made narrow or wide. When the chords are tight and the slit is narrow, a high tone is produced. When the chords are loose and the opening is wide, a low tone is produced. The chords are set in vibration as the air passes between them, and sound is made just as it is in a music pipe.



2. In a piped instrument, like an organ, there must be a pipe for each note. A single pipe, with a single pair of chords in the human throat, makes all the varied tones of the voice. This is effected by a change in the tension of the chords and the width of the glottis, and by changes in the width and length of the windpipe.

3. Sounds are made in the voice-box. They are shaped into words, and are otherwise modified in the cavities of the throat and head and mouth.

4. Voices differ in strength and quality. All voices can be improved by cultivation. Distinctness of utterance is especially desirable.

5. American voices are justly criticized by Europeans as being too high-pitched and shrill. We should cultivate the deeper tones as they do.

VII

Effects of Alcohol and Tobacco upon the Lungs.

1. We have seen that alcohol paralyzes the nerves in the walls of the small blood-vessels, causing them to expand and hold more blood than they should. It affects in this way the blood-vessels in the lungs. The blood then does not properly circulate through these important breathing organs, and they become liable to disease. Persons who drink alcoholic liquors contract colds easily, because the mucous membrane of the throat and lungs is weakened by alcohol, and thus is more liable to inflammation from slight causes.

2. When alcohol is taken up by the blood, some of it soaks through the blood-vessels upon the delicate tissues of the lungs themselves, and injures them in proportion to the amount that reaches them and the frequency of its presence. It is a matter of common medical testimony that the use of alcohol is a fruitful cause of lung diseases.

3. An eminent English physician,[1] who has had an extended connection with a hospital for consumptives in England, says that among the beer-drinkers is frequently found a general congestion of the small blood-vessels,—a tendency to hemorrhage, and a more or less thickened condition of lung tissue. And he adds that, "when such lungs break down, the secretion is more likely to be profuse, and the destruction rapid."

[1] R. E. Thompson, M. D., Senior Assistant Physician and Pathologist to Brompton Hospital for Consumptives.

4. A form of consumption, resembling the consumption of beer-drinkers, is frequent among the free drinkers of wine.[1] Anything which lowers vitality, while at the same time it injures the lungs, is a predisposing cause of consumption. Medical men are discovering that alcohol is a cause of this disease. In the British army stationed at home, where the soldiers obtain alcoholic liquors with little or no restraint, the two most frequent causes of death are *delirium tremens* and consumption. One form of fatal lung disease is now called alcoholic consumption, because it is known to be caused by the use of alcohol. It has also been observed that the children of drinking parents often inherit a tendency to consumption.

5. Tobacco, as well as alcoholic liquors, often produces a chronic catarrh of the throat and nose.

ILLUSTRATIONS.

1. Get from the druggist's a tumblerful of lime-water. With a glass-tube blow the breath through it, and it will become turbid by the union of carbon dioxide of the breath with the lime.

2. Voice-box, windpipe, and lungs can easily be obtained from the butcher's. The structure of the tubes can be tested and their divisions. The light and cellular structure of the lung can be shown.

3. A bellows illustrates well the action of breathing.

QUESTIONS.

I

1. What bodily need is more pressing than the need of food and drink?

2. What is air?

[1] Dr. A. B. Palmer: *Science and Practice of Medicine*, page 294.

3. What act is constantly repeated through life?

4. How much air do we take in with each breath? What is the composition of air that is breathed out?

5. How does expired air compare with inspired air in its composition?

6. What is the use of nitrogen in the air?

7. What is the use of carbon dioxide in the air?

8. State one point of difference between city air and country air.

9. What is the place of oxygen among the chemical elements?

II

1. How do the lowest orders of animal life take in oxygen? Why may not the higher animals take it in the same way?

2, 3. How does the frog take in oxygen? How do fishes take in oxygen? Why does a land animal need a different apparatus?

4. What are the lungs?

5. Where do the respiratory passages begin?

6. Does the mouth really belong to the respiratory passages? What reason for breathing through the nose rather than the mouth?

7. What is snoring?

8. Describe the throat and the openings into and out from it.

9. Describe the larynx; the vocal chords.

10. What is the glottis?

11. Describe the windpipe.

12. Why has it cartilage in its walls?

13. Why are the rings of cartilage incomplete?

14. What are the bronchi?

15. What are the bronchial tubes?

16. To what may the windpipe and its branches be compared?

17. Trace the blood-vessels from the heart to the lungs and back.

18. To what may the blood-vessels of the lungs be compared?

19. What holds the vessels and air-tubes together?

20. What is the pleura, and what is its use?

21. What is pleurisy?

22. Are the lungs well adapted to their purpose?

III

1, 2. What is the process of breathing and why is it necessary?

3. Can breathing be suspended at will?

5. Describe the chest.

6. Describe the diaphragm.

7. What are the respiratory muscles?

8. In what respect is the chest a remarkable box?

9, 10. What makes the chest expand in breathing? What makes the air enter? What makes it go out?

IV

1. What color has the blood in the right side of the heart? in the left side of the heart? Where do the changes of color take place?

2. What causes the changes of color?

3. What is the work of the red corpuscles?

4. What part of the blood takes up the most carbon dioxide? Where is carbon dioxide given off?

V

1. What is pure air?

2. What makes air impure? How does nature preserve the purity of the air?

3, 4. Why is it so difficult to secure pure air for breathing?

5. What is a good test of the character of air?

6. How should we try to secure pure air?

VI

1. Describe the voice-box.

2. How can a single tube, with the voice-box, make so many different notes?

3. Where are sounds shaped into words?

4, 5. What can you say of cultivation of the speaking voice?

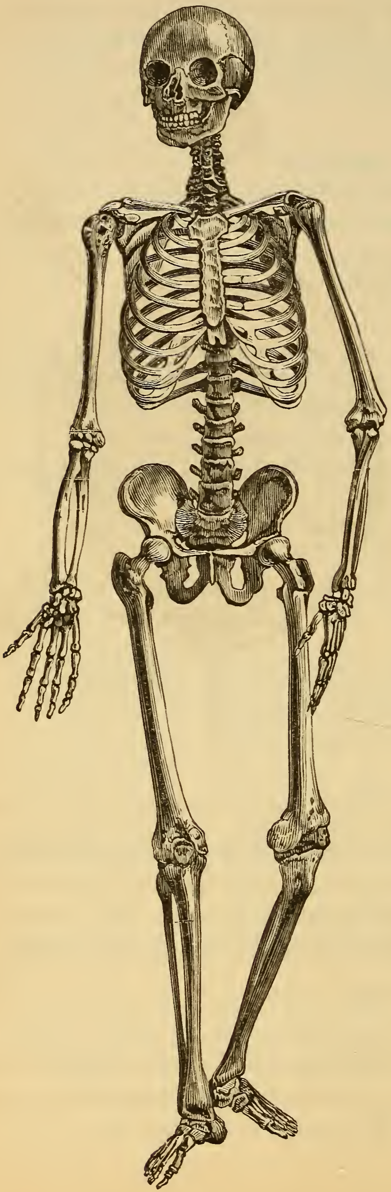
VII

1. What effect has alcohol on the blood-vessels of the lungs?

2, 3. How does alcohol affect the substance of the lungs?

4. What disease of the lungs is caused by alcohol?

5. What effect has tobacco on the throat and nose?



CHAPTER IX.

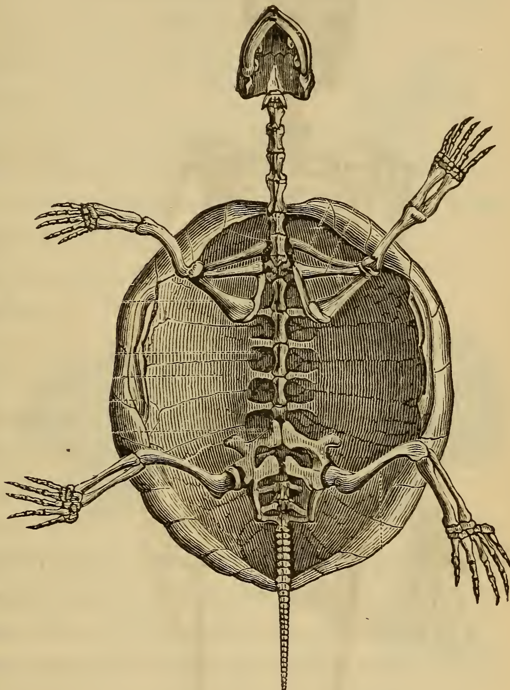
BONES AND JOINTS.

I

1. There is a vast number of animals constituting the lower orders, and their bodies are composed of soft material only. They float in the water and the air, or they crawl upon the earth. Such are the *infusoria*, that the microscope reveals in a drop of water, and such are worms and larvæ.

2. But all higher animals have a hard frame-work, to which the muscles and other soft parts are attached. This frame-work may be on the outside, and serve as a defense. This is the case in shell-fish and in turtles and snails, or it may be inside and covered with soft parts. This is the case in animals that have a backbone (vertebrates).

3. The substance which constitutes the frame-work of the human body is called bone.



4. Bone is hard and strong, and slightly elastic. In living bodies it is pink in color. Old, dead bones are white.

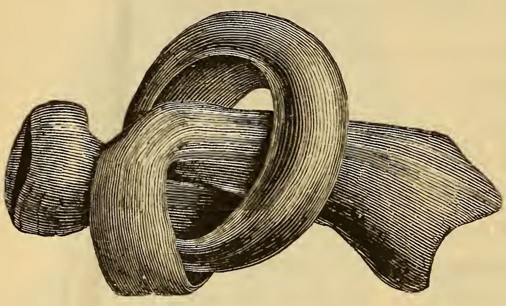
5. Bone is made of mineral matter and animal matter combined. If bone be put in the fire, the animal matter is burned out, and you have only the mineral matter remaining. But the form of the bone is preserved, although it is very brittle. If a bone is allowed to soak for ten days in a weak solution of hydrochloric acid (12 per cent.), the mineral matter will be dissolved, and only the animal matter will remain, preserving the form of the bone. A bone thus treated loses its hardness, and is so flexible that it may be tied in a knot.

6. Mineral matter constitutes two-thirds of the bone of all living creatures. Animal matter constitutes one-third of the same.

Bone consists of, — parts in 100, —

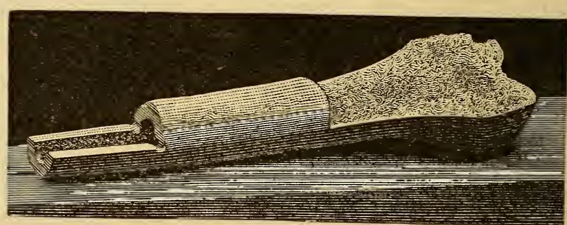
Phosphate of lime	53
Carbonate of lime	11
Other salts	3
Animal matter	33
TOTAL	100

7. Some of the bones are long, some are flat, and some are very irregular in shape. A long bone has a shaft which is comparatively slender, and two ends that are enlarged.



8. If you saw through the bone crosswise, and also lengthwise, you find that the shaft is very hard, but has a canal in it, while the end has only a thin layer of hard bone on the surface; and within it is made of a kind of honeycomb of bone, with no central canal. The short and flat bones are made like the ends of the long bones, with layers of hard bone on the surface, and a honeycomb mass within.

9. Take the thigh-bone (*femur*) as an illustration of a long bone. The shaft, on which thick muscles lie, is made slender to occupy as little room as may be. Its substance is very hard and compact to



give it strength The ends are expanded, because numerous muscles must find room for their attachments there, and because a large surface is needed for the joints. But these are all honeycombed within to make them lighter.

10. It is a well-known principle, that a hollow shaft is stronger for support than a solid shaft of the same material and of the same weight. The construction of the bones is such as to combine strength and lightness in a high degree.

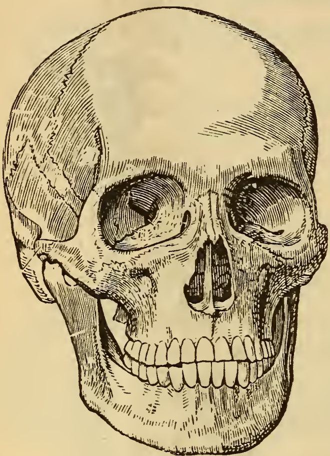
Formation and Growth of Bone.

11. In the newborn infant none of the bones are fully formed. Its skeleton consists in part of cartilage. This is gradually changed to bone. But the process is not completed until twenty-five or thirty years of age. In childhood the bone itself is less brittle than in later life. The skeleton of a child is accordingly much more flexible in its nature than that of a person of mature years.

Uses of the Bones.

12. The bony frame has two principal uses. First, it encloses and protects important organs. The chest contains the heart and lungs. The abdomen contains the stomach and other organs of digestion. These last are not wholly surrounded by bone, as the heart and lungs are. It is necessary that there should be freedom of motion at the waist, and therefore there is no bony wall in front.

13. The skull is a tight box to hold the brain. The openings into and out of it are small, and its shape



is such as to resist great pressure, or severe blows. The organs of special sense,—the eye, the ear, the nasal cavities, and the tongue,—are contained in the skull.

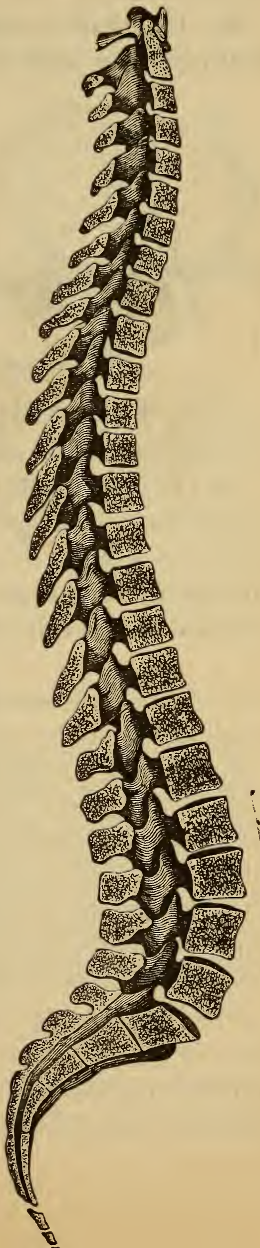
14. From the cavity of the skull a canal goes down through the backbone, which lodges the spinal cord. The backbone is exceedingly well adapted to hold and protect this principal organ. Strong, bony prominences stand out from it, and these are overlaid by muscular masses. Only great force can reach or disturb the spinal cord. The cord does not fill the canal, but hangs in the center of it, so that it is not liable to be pinched by the movements of the bones of which the spinal column is made.

15. Besides protecting internal organs, the bony frame gives shape to the body; it gives steady support to the soft parts, and enables us to stand and move as we could not do without it.

16. There are two hundred bones in the body of an adult. Before the bones are completed, a single bone is often represented by two or three pieces, so that the number of bones in a child would be much greater. The six very small bones of the ears are not included in this number; neither are the teeth, which are not true bones. The sesamoidal bones, found in the tendons, are not included.

The bones are classified as follows: —

In the skull			22
In the spinal column			26
In the trunk	Ribs	24	26
	Sternum	1	
	Hyoid	1	
In the upper limbs			64
In the lower limbs			62
Total			200

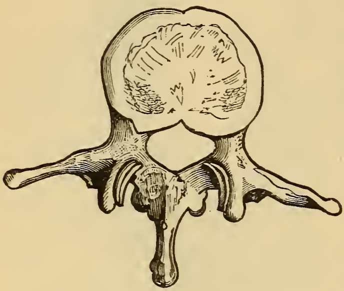


17. The skull is composed of flat and irregular bones united by close and immovable joints. Most of the bones of the skull are in pairs.

18. The spinal column is made of twenty-six distinct bones (vertebræ), quite odd in shape. Each has a central opening in it; and when they are united in a column, these openings make the canal which encloses the spinal cord.

19. The spinal column is well fitted for its work. It must be very strong to support the weight often placed upon it. It must be capable of bending and twisting in different directions. It must have elasticity enough to break the force of jars sustained in jumping and running. This latter quality it has by reason of the cartilages interposed between the vertebræ, and also by reason of the curves in it.

20. The spinal column is never perfectly straight; if it were, every step would jar the brain. It curves back between the shoulders and forward in the waist. Thus the skull is poised, not as on the top of a stiff rod, but as on a bent spring.



21. But the head should be held erect. A round back, and a head bent forward, are marks of old age. All labor tends to bring them into that position, and when the muscles lose their elasticity it becomes fixed.

22. Feeble health will cause stooping shoulders and a contracted chest. Indolent and careless habits may do the same thing. An effort should be made to cultivate an upright bearing in sitting or standing. It is more graceful and healthful.

Curvature of the Spine.

23. The spine sometimes curves to one side as well as forward. This occurs in delicate children, and is promoted by sitting sidewise at a desk with one arm on it and the shoulder raised, as in writing. When, after two or three hours of sitting, the head feels heavy and the body settles down into a bent position, a good run and some fresh air for ten minutes will straighten the spine.

The Ribs.

24. On each side there are twelve ribs, and they are joined to the backbone. Some of them are connected

in front with the breast-bone (*sternum*). These are called true ribs. Of the remaining five, called false ribs, three are joined with the ribs above them. The lowest two, known as floating ribs, are quite short, and are attached only to the backbone.

25. The costal cartilages connect the seven true ribs to the breast-bone. They connect each of the upper three false ribs to the ribs above; and they form the tips of the two floating ribs. These cartilages are, in form and size, continuations of the ribs. Their substance is more flexible and elastic than bone. As the chest expands in breathing they twist outward, and by their recoil they contract the chest in expiration.

26. Nature has given to the chest-walls a flexibility that adapts them wonderfully to the work of breathing. This flexibility at the same time makes it easy to press them out of shape. When any portion of the lung is gone, a depression soon appears in the chest-wall, and some diseases of the heart and lungs cause a bulging of the wall. Because there is no bony frame across the front of the body at the waist to resist pressure, a tight belt or tight clothing will press the waist out of shape. It is alike folly and sin to deliberately make a deformity by thus compressing the ribs with tight clothing. Such a course enfeebles the body by limiting the breathing powers, and by confining heart and stomach and liver

in too small a space. A small, tapering waist, squeezed out of its true proportion with the shoulders and hips, is no mark of beauty in the eyes of one of a cultivated taste. It is repulsive to an observer who has even a slight knowledge of the correct proportions of the human figure.

A pinched waist is a self-inflicted deformity, an indication of ignorance or a silly brain.

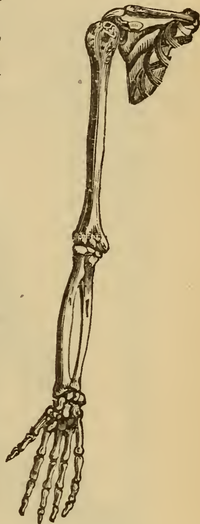
The Upper Extremity,

27. The shoulder-blade (*scapula*) and the collar-bone (*clavicle*) together make the shoulder. Notice that the shoulder-blade, while it lies upon the back, is not directly connected with the trunk.

The collar-bone is joined to the breast-bone in front. Both these bones are joined to the chest-wall by strong muscles. The shoulder, while it is very firm, has given to it a very free movement.

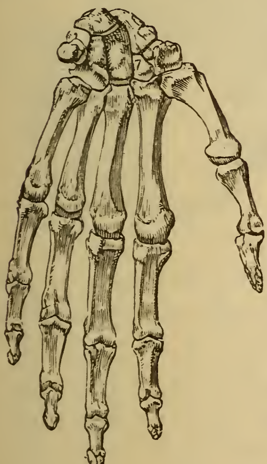
28. Observe the difference in this respect between the shoulder and the hip. The uses of the arm and hand make elasticity and free movement more desirable than great strength. The uses of the lower limbs make strength and firmness the most needed qualities. The hip-bone is therefore directly united with the trunk by a close joint.

29. Between the shoulder and elbow is one large bone (*humerus*). Between the elbow and the hand are two slender bones (*radius* and *ulna*). The radius is on the thumb side, and the ulna on the side of the little finger. The hand consists of *carpus*, *metacarpus*, and *phalanges*.



Carpus.

30. The carpus is made of eight little bones (carpal bones). At first it would seem as if they were crowded together at random, and might be of any shape. But a study of the wrist, and its movement, shows that each little bone is shaped with definite design; and that the combination of the eight secures strength and firmness, with freedom of motion in all directions in a remarkable degree.

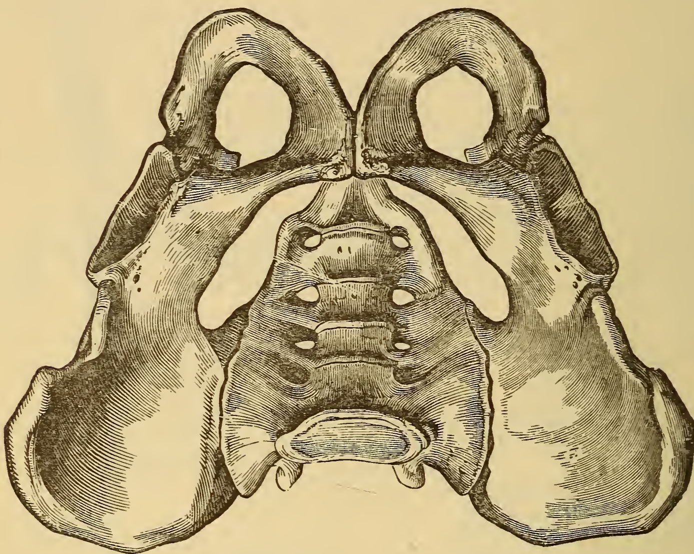


31. The palm of the hand has five (metacarpal) bones. These curve slightly, so as to make a hollow in the hand. Ligaments and muscles bind them together. They can be felt in the back of the hand, but are well covered in front.

32. The thumb and fingers have fourteen little bones, which are called phalanges, from a word meaning a line of soldiers, because they are arranged in order side by side.

The Lower Extremities.

33. The hip-bones are large and strong, and so irregular in shape, that the old anatomists who named the bones could think of no name which would describe them, so they called them the *ossa innominata* (unnamed)



bones. These two bones, with the last two bones of the spinal column (sacrum and coccyx), make a cavity called the pelvis (basin).

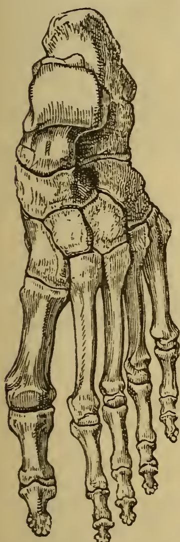
34. The pelvis encloses some of the internal organs, and at the same time it is an arch that supports the weight of the spinal column and the trunk, and transmits it to the bones of the legs.

35. The thigh-bone (*femur*) is the largest and longest bone in the body. This bone, with the thick muscles

attached to it, has much to do with the strength and grace of movement in an upright posture. Monkeys and the lower tribes of men have short thigh-bones. In the higher orders of men they are longer.

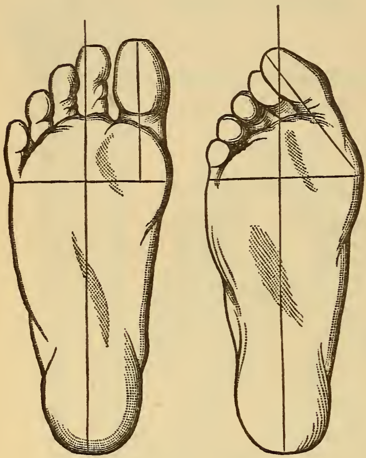
36. Between the knee and ankle are two bones (*tibia* and *fibula*). The tibia, or shin-bone, is next in length to the femur.

37. The frame-work of the foot is similar to that of the hand. The hand has *carpus*, *metacarpus*, and *phalanges*. The foot has *tarsus*, *metatarsus*, and *phalanges*. In monkeys the foot and hand are used for similar purposes, and do not differ as much in the details of their structure as they do in man. The human foot being designed solely for support and movement, the bones form an arch. This arch is the highest in the more highly developed races. The arch gives a spring to the step, and makes walking easy. Flat-footed persons are not good pedestrians.



38. Man is distinguished from the lower animals by his erect position, and his dignified and graceful movements. The gait is an indication of character, and may contribute much to the expression of manly dignity and womanly beauty. It is surprising, therefore, that civilized people should deliberately cripple the feet, so as to make ease and grace of motion impossible.

No woman can walk becomingly with a narrow French heel under the middle of her foot, and no man can step freely and smoothly with his toes crowded together by a narrow, tight boot. The feet of the majority of the Americans and Europeans of adult age are deformed.



39. To secure a well-developed figure, it is important to avoid awkward and cramped postures in sitting or standing. Free exercise of the muscles improves the shape. Narcotics and such like substances that poison the blood interfere with the growth of the bony frame-work. Boys who use tobacco are liable to be stunted.

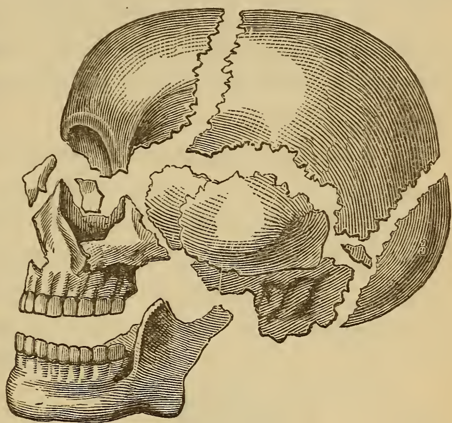
II

The Joints.

1. The bones which compose the skeleton are united by joints of different kinds. Each one is adapted to the needs of the part to which it belongs.

2. In the skull, for example, motion between the bones is not necessary after birth. We have there immovable joints. The flat bones are firmly united by their edges, which are made with points, like the teeth of a saw, so that they can lock together. By middle life some of them have grown together, so that they cannot be separated.

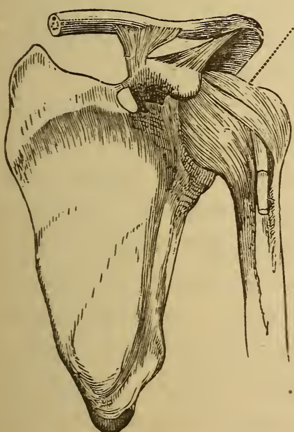
3. Between the vertebræ that comprise the backbone are joints that have very slight motion. Their bony surfaces are united by cartilage that twists or yields a little. These, and a few others like them, are slightly movable joints.



4. When we speak of joints in the body, we commonly think of those that are movable only. They are more numerous than fixed joints.

Structure.—Parts Composing a Joint.

5. The bones entering into them are covered with a thin layer of cartilage (gristle) that never changes into bone as some cartilages do. Its surface is very smooth. Bands of fibrous tissue, called ligaments, surround the joints and hold the bones together. These are generally loose enough to allow some separation of the surfaces of the bones. They are not elastic. When a bone gets out of joint, it must break through the surrounding ligament. The proper way to restore a dislocated

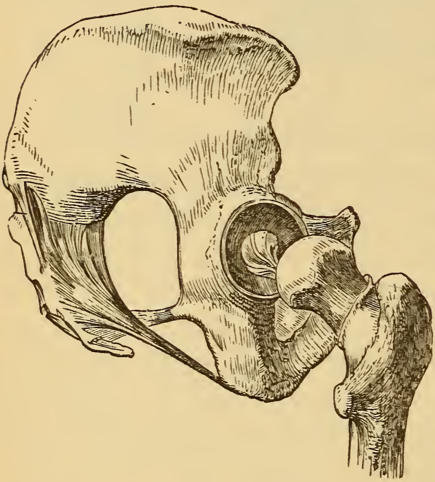


joint is to make the end of the bone pass through the

hole in the ligament by which it came out. This can often be done by a skillful person with very little force.

6. A sprain is an injury by which the ligaments of a joint are torn and stretched. The ligaments are often helped to hold the bones in place by muscles which pass over the joints.

7. Perhaps the most remarkable thing about a joint is its lining. The cavity between the bones is lined by a very thin membrane, called the synovial membrane. This membrane pours out the fluid that keeps the joints smooth. The joints of machinery need frequent oiling, to prevent them from rusting or wearing out too fast.



The human joint must also be "oiled," and it makes an oil of its own. Just enough of this oil, or joint-water, is always found in the cavity to make the surfaces play together, without noticeable friction.

8. Some of the joints are simply two flat surfaces, which glide upon each other in different directions. Such are to be found in the *carpus* and *tarsus*. Some of the joints are like a hinge. The bones can move only backward and forward as a door does. The elbow is a hinge-joint. There are two ball-and-socket joints. These are the shoulder and the hip. They permit the limb to be moved about in every direction.

9. In early life the joints are very flexible, and permit of free and graceful movements. In old age they become stiff, and the movements of the limbs are slow and constrained. Rheumatism, and other diseases which affect the joints, make a young person feel and move like one who is infirm.

III

Effect of Alcohol on the Bones and Joints.

1. Gout is a very painful and often a dangerous disease of the joints, induced by rich food and the use of alcoholic mixtures. Sometimes the disease is inherited from drinking parents by persons who have never used such drinks themselves.

2. As alcohol is capable of hindering and impairing the development of any of the various tissues of the body, the bones, which are its frame-work, may suffer also from its use. It is conceded that it is the nature of tobacco, as well as alcohol, to stunt the development of the bony frame, and dwarf the growth of children and young persons who are foolish enough to use these poisonous substances.

3. Youth is the period for growth and development. If growth is stunted during youth by the use of cider, beer, wine, tobacco, or by any other vicious habits, it cannot be afterwards made up. Stature and ability thus dwarfed will always be so much less then they might have been.

4. Smoking, drinking, and other evil habits in youth, sometimes called "sowing wild oats," reduce the power of enjoying the true pleasures of youth, and also yield a harvest of pain and loss in after years.

ILLUSTRATIONS.

1. Show a fresh bone and a dried bone. Get the boys to saw bones in various directions and investigate their internal structure. Soak a bone in a twelve per cent. solution of hydrochloric acid for a week to dissolve the animal matter. Burn a bone and show it as it appears when the amimal matter is removed.

2. Obtain, if possible, specimens of all the bones described.

3. Show the joints in the leg of a chicken or of a lamb. Point out the ligaments and cartilage.

QUESTIONS.

I

1. What part of the animal kingdom is without bones or other hard frame-work?

2. What two kinds of hard frame-work in animals?

3, 4, 5. Describe bone.

6. What is its chemical composition?

7. What shapes have the bones?

8. What is the difference in structure between the shafts and the ends of long bones?

9. Illustrate by the thigh-bone.

10. Why are the bones hollow?

11. Is the skeleton of a newborn infant all bone?

12. What are two principal uses of the skeleton?

13. Describe the skull.

14. Describe the spinal canal.

15. Could we stand erect without the skeleton?

16. How many bones are there in the body? How many in each part?

17. What kind of bones form the skull?

18, 19. What are the vertebræ? How are they adapted to their purpose?

20. Is the spinal column perfectly straight?

21, 22. What causes stooping shoulders?

23. What causes curvature of the spine?

24. How many ribs have we? How are these classified?
25. Describe the costal cartilages.
26. What is the effect of tight clothing?
27. What bones constitute the shoulder?
28. What difference between the shoulder and the hip?
29. Where is the humerus? the radius and ulna?
30. What is the carpus?
31. What is the metacarpus?
32. What are the phalanges?
33. Describe the hip-bones.
34. What is the pelvis?
35. Describe the thigh-bone.
36. Describe the tibia and fibula.
37. Describe the frame-work of the foot. What is the difference between the frame-work of the feet and of the hands?
38. How are the feet often crippled?
39. How may the figure be improved?

II

1. How are the bones of the skeleton united?
2. Where do we find immovable joints?
3. What is the character of the joints between the vertebræ?
4. Which are more numerous in the body — the movable or immovable joints?
5. What are the parts composing a joint?
6. What is a sprain?
7. How are the joints kept smooth?
8. Mention some of the different kinds of joints.
9. What change takes place in the joints in old age?

III

1. What is gout, and how may it be caused?
2. What effect may alcohol and tobacco have upon the bones?
3. If the development of the body is checked in youth, can the loss be afterwards made up?
4. What permanent harm results from "sowing wild oats"?

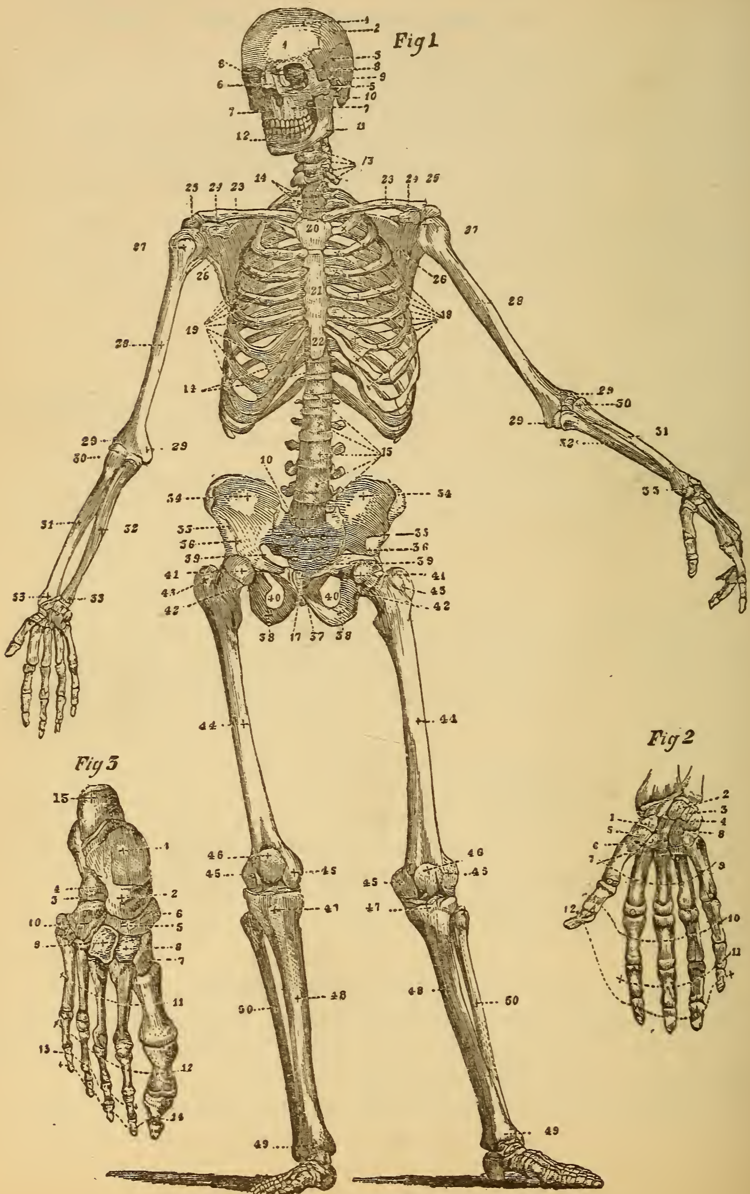


Fig 1

Fig 2

Fig 3

THE HUMAN SKELETON.

Bones of the Head, Trunk, Legs, and Arms.

1. Os frontis — Frontal bone.
2. Parietal bone.
3. Temporal bone.
4. Coronal suture.
5. Os malæ — Cheek-bone.
6. Ossa nasi — Nasal bones.
7. Superior maxillary — Upper jaw-bone.
8. Orbits.
9. Side of os occipitis — Occipital bone.
10. Condyloid process of lower jaw.
11. Angle of lower jaw.
12. Symphysis of lower jaw.
13. Four lower cervical vertebræ (seven in all).
14. Two upper and two lower dorsal vertebræ (twelve in all).
15. Lumbar vertebræ (five in number).
16. Os sacrum — False vertebræ.
17. Os coccygis.
18. Cartilages of ribs.
19. Ribs.
20. First bone of sternum, } Breast-bones.
21. Second bone of sternum, }
22. Cartilago ensiformis.
23. Clavicles — Collar-bones.
24. Coracoid process of scapula — Shoulder blade.
25. Acromion of scapula.
26. Venter of scapula, anterior surface.
27. Heads of os humeri — Arm-bone.
28. Body of os humeri.
29. Condyles of os humeri.
30. Head of radius — Outer bone of fore-arm.
31. Body of radius.
32. Ulna — Inner bone of fore-arm.
33. Carpal ends of radius and ulna.
34. Venter of ilium.
35. Anterior superior process of ilium.
36. Anterior inferior process of ilium.
37. Symphysis of pubis.
38. Tuberosity of ischium.
39. Brim of pelvis.
40. Foramen ovale.
41. Head of os femoris — Femur of thigh-bone.
42. Neck of os femoris.
43. Trochanter major of os femoris.
44. Body of os femoris.
45. Condyles of os femoris.
46. Patells — Knee-pan.
47. Head of tibia — Thick bone on anterior and inner side of leg.
48. Body of tibia.
49. Base of tibia.
50. Fibula — Thin bone on external side of leg.

Front View of Right Hand and Wrist.

1. Scaphoid bone.
2. Semilunar bone.
3. Cuneiform bone.
4. Pisiform bone.
5. Os trapesium.
6. Os trapezoides.
7. Os magnum.
8. Unciform bone.
9. Metacarpal bones of thumb and fingers.
10. First row of phalanges of thumb and fingers.
11. Second row of phalanges of fingers.
12. Third row of phalanges of thumb and fingers.

Front View of Right Foot.

1. Superior articulated surface of astragalus.
2. Anterior portion of astragalus.
3. Os calcis — Heel-bone.
4. Commencement of groove of interosseous ligament.
5. Scaphoid bone.
6. Tuberosity of scaphoid bone.
7. Internal cuneiform bone.
8. Middle cuneiform bone.
9. External cuneiform bone.
10. Cuboid bone.
11. Metatarsal bones.
12. First row of phalanges of toes.
13. Second row of phalanges.
14. Third row of phalanges.

CHAPTER X.

MOTION.

I

1. One thing that distinguishes animals from plants is, that they have the power of motion at will. Plants and non-living objects move only when they are acted upon by some force outside of themselves. There is a force residing in the animal body which enables it to move itself, and to impart motion to other objects.

2. The power of motion does not belong to all organs of the body, but principally to the muscles. Bones cannot move themselves, neither can ligaments nor nerves nor fat. There are, however, besides the muscles, two other elements of the body that can move.

3. By watching the white corpuscles of the blood with a microscope, it has been found that they can move. They are round bodies and have no organs of motion, but they have a way of their own of traveling.

4. Some part of their surface bulges out and continues to swell, until the whole globule has gone into the swelling, and so has changed its position a little. If now another swelling appears in the same side, and the globule goes into it in the same way, it will have moved a little further, and so on indefinitely.

5. Again, if the lining of the breathing passages be carefully observed with a powerful microscope, it will

be seen to be overspread by what appears like a crop of wheat in the field. Numberless little stems stand upright as the stalks of wheat do, and they are all moving as the wheat moves when a breeze blows over it. It is a waving motion, — a quick stroke in one direction and then a slow movement back again, like the strokes of a broom when one is sweeping the floor. Indeed, that is what these waving stems are doing. They are sweeping the dust, which comes in with the breath, and the phlegm which gathers in the bronchial tubes, up towards the mouth. The quick stroke is always in that direction; the return is slow.

6. These little stems are like fine hairs, and therefore they are called cilia (*cilium*, a hair). They are not muscles, but they have the power of moving as muscles do.

7. These cilia are found not only in the breathing passages, but in some other tubes in the body. Their work always is to keep the fluid that moistens the lining of the tubes in motion in one direction.

8. The muscles are the chief organs of motion, and there are two kinds, —

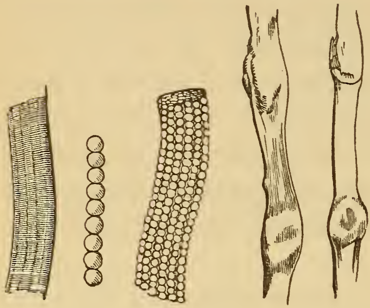
VOLUNTARY MUSCLES. INVOLUNTARY MUSCLES.

The Voluntary Muscles.

9. The voluntary muscles cover the bones, and are attached to them. For that reason they are sometimes called skeletal muscles. They give a rounded and graceful outline to the body.

10. Muscle is lean meat. The roasting-piece of beef and the slice of steak are muscle. If you should examine the flesh of the animal after the skin has been removed, you would find that the lean meat on the limb

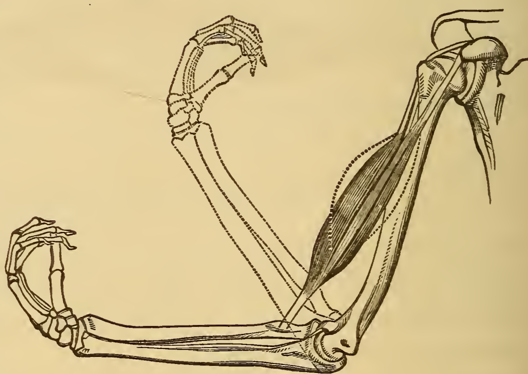
or in the trunk is made up of bundles of flesh, each enclosed in a sheet of tough, stringy, white tissue, and joined by threads of this same white tissue (connective tissue) to other bundles. This structure can easily be



seen in any slice of meat cut "across the grain." There are large bundles, and they are made of smaller bundles. The smallest bundles of all are made of muscle-fibers.

11. These fibers can be discerned only with the mi-roscope. They measure not more than one-four-hundredth of an inch (63 mmm.) across. It is in them that the power of motion resides.

12. When seen under a microscope the fibers of voluntary muscles have lines running across them, and are thereby known as striped muscles.

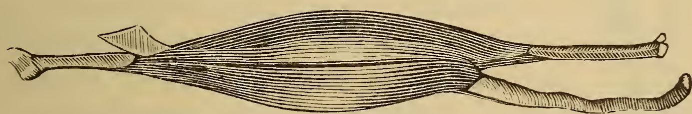


13. The muscle moves and makes other things also move, by growing shorter and thicker. This is most readily noticed in the biceps-muscle of the arm. When we desire to bend the elbow, this muscle swells and shortens, the arm-bone to which it is attached is drawn up, and the hand approaches the shoulder.

14. All the voluntary muscles are attached to the bones — most of them to two bones. As a muscle shortens, one of these bones is drawn toward the other. So all the movements of body and limbs are produced.

15. The muscles act upon the bones as upon levers. Sometimes it is the short arm of the lever that is acted upon. A swift motion of the long arm is the result. Sometimes the long arm is acted upon. A slow but powerful movement of the short arm is the result. Sometimes one end of the bone is fixed, and the muscle is attached at the other end, or in the middle of the bone.

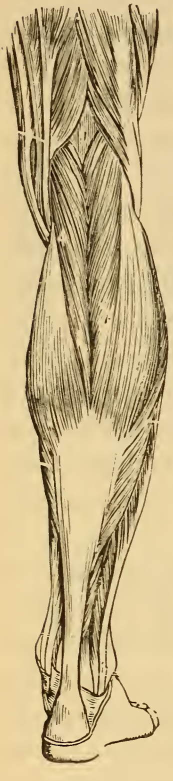
16. Muscles are of various sizes and shapes. Some are flat, and some are round. Some are short, and some are long. The longest is a ribbon-like muscle in the thigh, called the *sartorius* (tailor's muscle), which



may be two feet long. The shortest is a little muscle of the ear which is not more than one quarter of an inch in length.

17. Most of the voluntary muscles end in tendons, by which they are attached to the bones. Tendons are what we know as the "cords" in the body. You can see and feel them in your wrist; when the muscle of the fore-arm contracts and doubles the fist, the cords stand out. When there is not much fat over the muscles the tendons show very plainly. The largest and strongest tendon in the

body is the tendon of Achilles,[1] which attaches the great muscle of the calf of the leg to the heel.



18. There are more than five hundred muscles in the body, and every muscle has been named by the anatomists. But nearly all the muscles are in pairs, the two sides of the body being exactly alike.

19. A muscle seldom acts alone. Several muscles are grouped together to make a certain movement. Different groups are opposed to each other in action. For example, the muscles on the front of the arm that bend the joints are opposed by the muscles on the back of the arm that straighten the joints. By the continued action of various opposing groups, all the movements of the body are effected. Some simple acts, — walking, for instance, — involve many muscles and very complicated movements.

The Involuntary Muscles.

20. The black spot in the center of the eye, which is called the pupil, is sometimes large and sometimes small. When the light is strong, it is small. In dim light it grows large. By shading with your hand some one's eye, and then removing the hand suddenly, you can see the change taking

[1] The legend relates that Thetis, the mother of Achilles, dipped him, while an infant, into the waters of the Styx, making him invulnerable, except where her fingers held him by this tendon. He was finally slain by an arrow which wounded him in this spot.

place. The pupil is a hole in the iris. The iris,—the colored part of the eyeball,—is a membrane made in part of muscle-fibers. These fibers run in different directions. Part of them surround the pupil in rings, and part of them run from the edge of the pupil straight out like the spokes of a wheel. When the circular fibers contract, it makes the pupil small. When the straight fibers contract, it makes the pupil large.

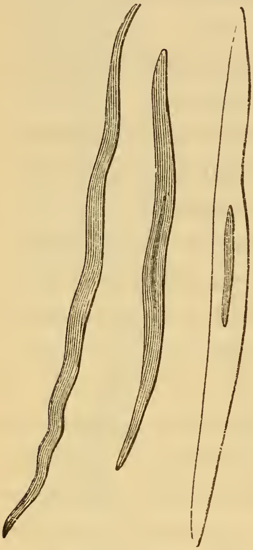
21. But you cannot make these fibers contract by your will alone. If you will to move your hand or your leg, it moves instantly. In some way your will can make these muscles contract. They are voluntary muscles; but you may will as earnestly as you please to have the pupil of the eye grow larger or smaller, it does not change in this way. These muscle-fibers will not obey your will. They are involuntary. If you change your position, so that a brighter light will fall on your eye, they will act at once.

22. The iris is the best example of involuntary muscle to be seen on the outside of the body. But the movements of all the organs within the body are made by involuntary muscle-fibers. They are found in the wall of the alimentary canal, in the bronchial tubes, in the heart, in the blood-vessels and lymphatics, and in every internal organ which has the power of motion.

23. In this way Nature not only relieves us of the burden of maintaining these movements of the vital organs, by exercise of the will; she also withholds from us the power of checking or stopping them at will.

24. The involuntary muscles are different in structure from the voluntary muscles. The fiber of striped voluntary muscle has already been described. The fiber of

involuntary muscle is shaped like a spindle and pointed at both ends. The fibers of voluntary muscles are joined in bundles, like the strands in a rope. The fibers of involuntary muscles are joined by their ends, which lap over each other, and they are either scattered through the tissue in which they are, as in the skin, or they form sheets of muscle, as in the wall of the alimentary canal. They are not attached to bones like the voluntary muscles.



25. The involuntary muscles differ from the voluntary in their mode of action. The voluntary muscles act very quickly. It does not take more than one-tenth of a second for a voluntary muscle to contract after the will determines it. The involuntary muscles act slowly.

26. The muscle of the heart is involuntary. We have no direct control over its action, but it differs in structure from the general voluntary and involuntary muscles. The heart muscle-fiber is very fine,—it is striped,—it branches and connects with neighboring fibers.

Muscular Exercise.

27. Our life can manifest itself only through muscular action. The man whose muscles are all paralyzed can hold no communication with the outer world either by gesture, speech, or glance. The greater part of the daily work of the world is done by the muscles. But among

civilized men the brain plays so prominent a part that the muscular system does not get proper consideration. The heroes of the primitive races are the strong and agile of body. The heroes of cultivated races are the mentally vigorous and learned.

28. We need to take care that the muscles get regular exercise. A cultivated mind in a strong body has an advantage over the same mind in a weak body; and no part of the body can be neglected without crippling to some extent the rest.

29. Use makes the muscles grow in size and firmness. An arm or leg which has been broken and kept in splints always shrinks in size, because it is not used.

30. It is not important to have very large muscles. Great strength is useful only in a few occupations, but it is very desirable to have the muscles firm and active and well-proportioned.

31. For those who are sitting much of the time, and for those whose work is chiefly brain-work, muscular exercise is rest. Rest is not always gained by ceasing from work. The tired brain-worker often lies awake for hours after retiring, the brain refusing to be still and the muscular system restless and uncomfortable. A walk of a mile, or exercise for half an hour with dumb-bells, will draw the blood from the brain and give the muscles their needed refreshment, and insure the wished-for sleep.

32. Muscular exercise makes the blood flow more swiftly through all the tissues, removing waste matter and giving oxygen.

33. Muscular exercise should be taken regularly. One who exercises only occasionally, as inclination urges, will not get as much profit or enjoyment from it as one who exercises for some time every day.

34. Exercise that is taken with pleasure is very much better than enforced exercise. Children and all young animals, even the fiercest, play a great deal. Exercise is especially needful for them because they are growing, and so Nature implants in them a love for play which keeps them active. It is well that children should be instructed in useful work that gives them exercise. But nothing should be allowed to deprive a child of all opportunity for play.

35. Exercise taken in the open air is more beneficial, both in summer and winter, than in-door exercise. Part of the good got from it is due to the oxygen of the air.

36. Do not exercise too long or too violently. Young people sometimes do themselves severe injury, when spurred by ambition to exert themselves too much in this way.

37. Violent exercise should not be taken immediately before or immediately after eating. It draws the blood from the stomach at a time when it is needed there. Dyspepsia is often caused in this way.

38. Girls need exercise as well as boys. It is a mistake to check their natural impulse to it through false ideas of propriety. They should rather be encouraged to take exercise. It is unfortunate that the dress of women is such as to hinder free movement.

39. Girls who are fond of open-air exercise, who run and take part in vigorous out-door games, usually grow to a more healthy and vigorous womanhood than those who do not. Walking, lawn tennis, archery, and croquet are good forms of out-door exercise for girls who have outgrown childish plays. But no one can ever outgrow the necessity for spending some time each day in some

active exercise in the open air, for which we should plan as regularly as for our meals. The health necessary to usefulness, enjoyment, and beauty is soon lost by shutting one's self up in the house.

IV

Alcohol and the Muscles.

1. The strength of a muscle consists in its power of contraction,—that is, its power to swell and grow shorter, thus moving itself and other things. Alcohol reduces this contractile power. "A moderate dose of beer or wine will, in most cases, at once diminish the utmost weight which a healthy person can lift."[1]

2. Muscle becomes exhausted by exercise sooner when an alcoholic drink has been taken than when it has not. The workman who takes beer or wine to strengthen him, or "brace him up," as he says, cannot endure so long a strain of hard work as one can who does not take these drinks. Neither will his muscles be steady and precise enough to do fine work. The shaking hand and unsteady nerves of the habitual drinker are not the only proofs that alcohol injures the muscles. A champion English rower once refused to take a doctor's prescription of wine, by saying that he should not win his race if he did. He explained that in order to win, an oarsman must have precision, decision, presence of mind, and endurance, and these he cannot have if he takes alcohol.[2]

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[1] Dr. William Brunton.

[2] This oarsman gave as an illustration of his belief an account of a race he once rowed with another oarsman fully as competent as himself, and who at the start had some slight advantage

3. A famous oarsman says, that in his opinion the best physical performances can only be secured through absolute abstinence from the use of alcohol and tobacco.

4. Alcohol is very likely to cause a fatty degeneration of the muscles. The blood being improperly purified, carries about with it little particles of fat, which are deposited between the minute muscular fibers. When this fat gathers in large quantities, it crowds upon the muscular fibers and interferes with their action.

5. Sometimes, instead of this deposit of fat between the muscular fibers, or together with it, there is a gradual change of the lean muscle itself into fat. This is called fatty degeneration, and is liable to occur in the heart, liver, kidneys, arteries, and other parts of the body, as well as in the voluntary muscles.

6. Tobacco contains a poison, nicotine, which has special power for causing relaxation of muscles. Its chief action is upon the heart and brain, but the muscles are so affected by it that they soon lose their steadiness and precision. A drawing teacher of large experience says

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over him. But the other oarsman took a drink of whisky just as he stepped into his boat, while the one who related the story took none. When they had gone a little way the stroke of the one who had taken the whisky began to loose its precision; he allowed his attention to be diverted by the cheers of the spectators; he was not able to decide quickly as to the best course when they met with an obstacle, and before the goal was reached he began to flag. The other did not flag and won the race. Yet when he set out he was not feeling well, and had to take the side of the river that gave him the sun in his face all the way. His victory, he firmly believed, was due to the sip of whisky his opponent took in starting, while he kept his head clear and muscles steady by not taking any.

he can readily detect the boy who uses tobacco by his inability to draw a clean, straight line.

7. Tobacco and alcohol are enemies to good muscles, and those who never use them have the best chance of winning in the race of life.

ILLUSTRATIONS.

1. A piece of raw meat shows the structure of muscle. Tear out the fibers of a muscle with needles, and examine them with a power of three or four hundred diameters.

2. Illustrate the action of the muscles on the bones by using a ruler or a cane as a lever, and showing the different points at which the power and the fulcrum may be located.

QUESTIONS.

I

1. What is one of the most obvious distinctions between plants and animals?

2. In what parts of the body does the power of motion chiefly reside?

3, 4. Describe the movement of the white corpuscles of the blood.

5, 6. Describe the cilia and their movement.

7. What is the work of the cilia?

8. What two kinds of muscles are there?

9. Where are the voluntary muscles placed?

10. Describe a voluntary muscle.

11, 12. Describe a voluntary muscle-fiber.

13. How does muscle move and cause movement?

14. To what are the voluntary muscles attached?

15. How do muscles act on the bones?

16. Are muscles uniform in size and shape? Which is the longest muscle in the body? Which is the shortest muscle in the body?

17. What are tendons? Where is the tendon of Achilles?

18. How many muscles are there in the body? How many pairs of muscles are there in the body?

19. How do muscles combine in action?

20. What is the pupil of the eye? What is the iris? What makes the pupil dilate? What makes it contract?

21. What kind of muscle is in the iris?

22. Where else are similar fibers found?

23. Why are some muscles involuntary?

24. Describe the involuntary muscle-fiber.

25. What difference in action between voluntary and involuntary muscles?

26. What kind of muscle-fiber is found in the heart?

27. What part do the muscles play in our lives? Why are the muscles neglected among highly civilized men?

28. Does a strong body help the mind?

29. What is the natural effect of exercise on the muscles?

30. Is it important to have large muscles? What qualities are desirable in the muscles?

31. Is rest always gained by ceasing from work? How may exercise be rest?

32. What effect has muscular exercise on the circulation?

33, 34. How should exercise be taken in order to get the most profit from it?

Why does Nature make children love play?

35, 36, 37. Name some important conditions to be observed in taking exercise.

38, 39. Do girls need exercise as much as boys? Is exercise necessary for children only?

IV

1. What effect has alcohol on the contractile power of muscle?

2, 3. Will the muscles endure longer when alcoholic drinks are used?

What effect has alcohol on the steadiness and precision of muscular action?

4, 5. What change in muscle-fiber is caused by alcohol? What tissues besides the muscles may be changed by alcohol?

6. What effect has nicotine on the muscles?

7. Who have the best chance of winning in the race for life?

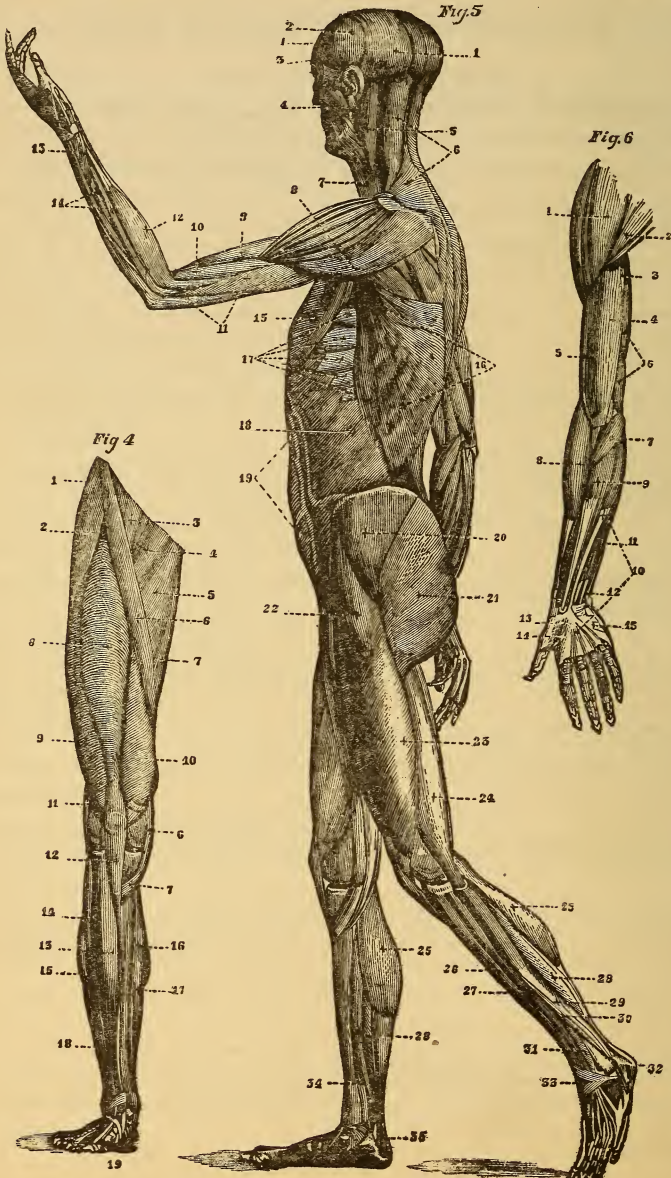


Fig.5
Fig.6
Fig 4

MUSCLES OF THE HUMAN BODY.

Side View of Full Figure.

1. Occipito-frontalis — Used to raise the eyebrows, etc.
2. Temporalis — Helps to elevate the lower jaw.
3. Orbicularis palpebrarm — Closes the eyelids.
4. Masseter — Helps to elevate the lower jaw, etc.
5. Sterno-cleido-mastoiedeus — Moves the head forward, etc.
6. Trapezius — Moves the head backward, sideways, etc.
7. Platysma myoids — Assists in depressing the angle of the mouth.
8. Deltoides — Raises the arm, etc.
9. Biceps flexor cubiti, } Act together on
10. Brachialis anticus, } the fore-arm.
11. Triceps extensor cubiti.
12. Supinator radii longus — A flexor of the fore-arm.
13. Extensor muscles of thumb.
14. Extensor muscles of wrist.
15. Pectoralis major, } Lower the arm
16. Latissimus dorsi, } when elevated, etc.
17. Serratus magnus — Assists in advancing the scapula, etc.
18. Obliquus externus abdominis, } Support the ab-
19. Rectus abdominis, } dominal viscera.
20. Glutæus medius, } Act alternately
21. Glutæus maximus, } on the thigh-bone and pelvis.
22. Tensor vaginæ femoris — Renders the fascia tense, etc.
23. Vastus externus — Contributes to extend the leg upon the thigh.
24. Biceps flexor cruris — Assists in bending the leg on the thigh, etc.
25. Gastrocnemius — Forms the calf of the leg, etc.
26. Tibialis anticus — With 31 bends foot on the leg, etc.
27. Extensor communis digitorum — Aids in extending the toes, etc.
28. Soleus. See 25.
29. Peronæus longus, } Act together in
30. Peronæus brevis, } drawing the foot back.
31. Peronæus tertius — Flexor of the foot on the leg, etc.
32. Abductor minimi digiti — Bends the little toe, etc.
33. Extensor pollicis proprius — Extensor of great toe.
34. Flexor communis digitorum — Bends the toes, etc.
35. Tendo Achilles — Junction of 25 and 26

Front View of Right Arm.

1. Deltoides. See 8 above.
2. Pectoralis major. See 15 above.
3. Coraco-brachialis — Assists to move arm backward and forward.
4. Biceps flexor cubiti. See 9 above.
5. Brachialis internus. See 10 above.
6. Triceps extensor cubiti. See 11 above.
7. Pronator radii teres — Turns palm of hand downward, etc.
8. Supinator radii longus — Turns palm upward, etc.
9. Flexor carpi radialis—Bends the wrist, etc.
10. Palmaris longus, with fascia — Bends the hand, etc.
11. Flexor digitorum communis — Bends fingers toward the palm, etc.
12. Flexor carpi ulnaris — Bends the wrist, etc.
13. Abductor pollicis manus — Carries the thumb outward, etc.
14. Flexor brevis pollicis — Flexor of first joint of thumb.
15. Palmaris brevis — A small muscle connected with little finger.

Front View of Right Leg.

1. Glutæus medius. See 20 above.
2. Tensor vaginæ femoris. See 22 above.
3. Psoas and iliacus — Bend the thing on pelvis, etc.
4. Pectineus — Contributes to bend thigh-bone, etc.
5. Abductor longus — One of the abductors of thigh.
6. Sartorius — Bends leg upon the thigh.
7. Gracilis — Acts along with abductor muscles of thigh.
8. Rectus femoris, } Extend leg upon the
9. Vastus externus, } thigh.
10. Vastus internus, }
11. Biceps flexor cruris. See 24 above.
12. Insertion of ligament of patella into tibia.
13. Tibialis anticus. See 26 above.
14. Extensor communis digitorum. See 27 above.
15. Peronæus longus. See 29 above.
16. Gastrocnemius. See 25 above.
17. Solæus. See 28 above.
18. Peronæus brevis. See 30 above.
19. Abductor pollicis pedis — Abductor of great toe.

CHAPTER XI.

THE NERVOUS SYSTEM.

I

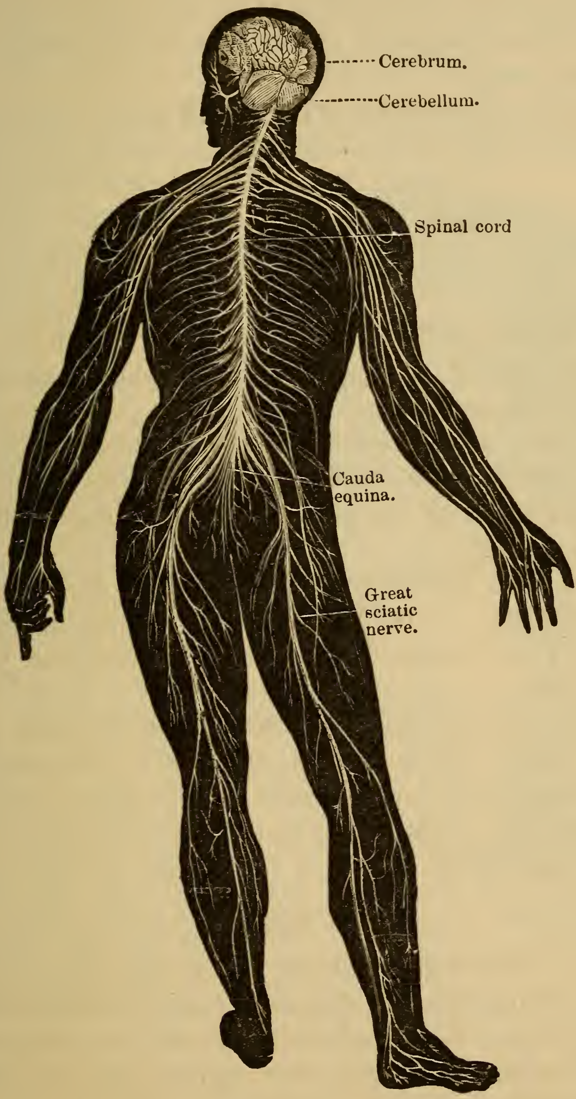
1. The human body is made of many members. Each member, — heart, stomach, lung, muscle, — has its own kind of work to do; but each must act in harmony with all the rest. It is like a country with many states, cities, towns, and villages, each having its own affairs, but each dependent on the others and combining with them in national life.

2. In order that they may so combine it is necessary, first, that they should have free communication and sympathy; and secondly, that there should be a general government.

3. The nervous system is the apparatus which brings the organs of the body into close communication with one another, and presides over and directs their action. The brain, the highest part of the nervous system, is the special seat of the mind.

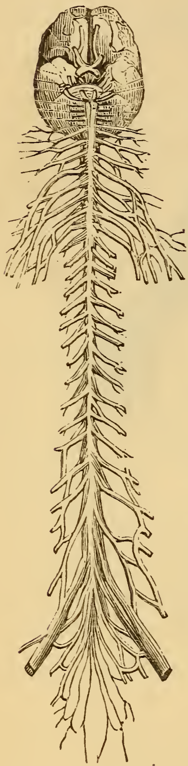
The Nerves.

4. In dissecting the body of any animal, in nearly all the tissues are seen delicate white threads which are called nerves. If one of these threads be followed up, it will be found uniting with other threads; and the bundle, so formed, uniting with other bundles, until at


Cerebrum.
Cerebellum.
Spinal cord
Cauda
equina.
Great
sciatic
nerve.

last many have become joined in one large cord, which may be traced into the spinal cord in the backbone, or into the brain.

5. Or starting from the brain and spinal cord, we find forty-three pairs of large white cords passing out through small openings in the skull and the backbone, and soon dividing into branches, each of which divides again and again until the little white threads are spread through all the tissues.



The Brain and Spinal Cord.

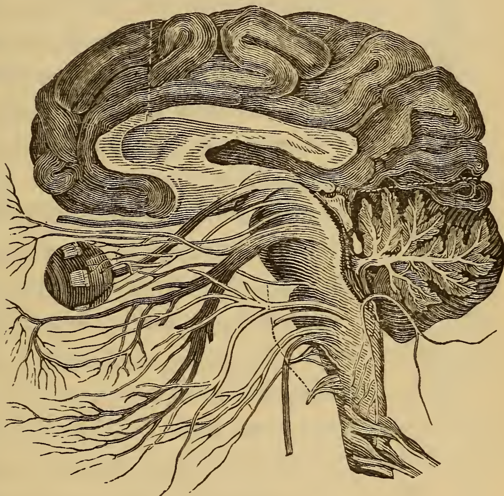
6. The brain and spinal cord are called nerve-centers. The brain is contained in the skull. It has about the consistency of new cheese, and weighs in a grown man about three pounds (1361 grms.).

7. The human brain is heavier than that of any other animal, except the elephant and whale. The elephant's brain weighs ten pounds (4536 grms.), the whale's five pounds (2268 grms.). In proportion to the weight of the whole body, the brain of man is much heavier than that of either of these large animals.

8. The spinal cord in man weighs about an ounce and one-half (42.5 grms.), one thirty-second of the weight of the brain. In the lower animals the cord is larger in proportion to the brain, and in some of the lowest of the animals, with backbones, the spinal cord is actually heavier than the brain. The brain is made up of several

parts easily distinguished. A deep furrow, running forward and backward, divides it into halves, which are alike. The brain is therefore a double organ.

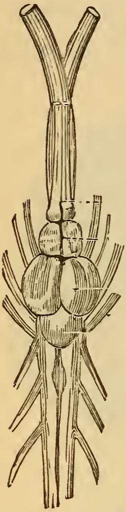
9. In man, the largest of its parts are the two hemispheres of the cerebrum or upper part of the brain, and these fill the vault of the skull. In the lower animals, the hemispheres are relatively smaller. In the ape and in domestic animals, they approach in size to the human. In fishes, which are the least intelligent of all the lower animals with a backbone (vertebrates), they are quite



small. Since in the animal world greater intelligence is always to be found associated with larger hemispheres, and since in man the hemispheres greatly surpass those of any other animal, it is inferred that the hemispheres are the seat of those higher powers of mind which distinguish mankind from the brute creation.

10. If the hemispheres of the brain be examined by dissection, they are found to consist of matter of different shades of color. On the surface is a layer of grayish matter about one-eighth of an inch ($3^{m.m.}$) deep. Beneath this, and forming the mass of the organ, is white matter. The white matter is made up of nerve-threads running

in different directions, connecting the different portions of the brain with each other and with the spinal cord. The gray matter consists principally of cells, in which the work of the brain is done. The amount of gray matter which a brain contains is an index of the work that it can do. In the higher animals, and especially in man, nature has a way of increasing the working portion of the brain without increasing the size of the whole. The surface of such brains, instead of being smooth, is thrown into folds, called convolutions, with furrows about an inch deep between them. The gray surface, being carried down into these furrows, is very much increased in extent. In the lower animals no such furrows are found; but in the higher animals, such as the horse and dog, they are very marked. In mankind they are more numerous and much deeper then in any other animal.



Brain of a Fish.

11. The characteristics which particularly distinguish the human brain from that of the brain of all the lower animals are its absolute size,—the relative size of the hemispheres,—and the number of the convolutions and depth of the furrows between them.

12. A large and well-proportioned head is a good, but not an infallible index of a superior brain. For the size of the brain does not absolutely determine the extent of brain surface, or the amount of brain power. Not only may the convolutions be more numerous in the smaller brain, but the quality may be superior. Mental power depends on the quality as well as on the quantity of gray matter.

13. The spinal cord extends down from the base of the brain through the spinal canal. From its sides come off at regular intervals the large, white nerve cords, which issue in pairs from the spinal canal on opposite sides, and send their branches to all parts of the body.

14. The cord does not fill the canal, but hangs loosely in it. For this reason it is not likely to be pressed and twisted, as the backbone is bent and turned. If in any way one of the bones called vertebræ, which make up the backbone, is put out of joint, it presses on the cord and causes paralysis of the body below. But these bones are very firmly joined, and this accident seldom happens.

15. Cut across a spinal cord, and you find it looks like a cut brain. It has gray and white matter, but the gray matter is in the center and not on the surface. The spinal cord connects the brain with the nerves. It also does an independent work which we will notice further on.

16. Each nerve is a bundle of nerve-threads, called fibers, and each of these fibers connects a point in the surface with a cell in the spinal cord.

Work of the Nerves.

17. The nerves are in some respects like telegraph wires, — they are conductors. If you touch a red-hot stove, the impression made upon the end of the nerve in your finger is carried up to the brain, and in some of the cells of the gray matter a sensation of pain is awakened. If you cut that nerve, you may hold your finger in the flame and have no sensation.

18. Again, the nerve which ends in the muscle of your arm carries the message from your brain, when you wish

the muscles to contract. If you cut that nerve the muscle no longer obeys your will.

19. If a man has fallen on his head, and driven one of the vertebræ out of joint, so that the cord is compressed, he has neither feeling nor power of motion in the parts below the injury, because the course of the nerves which convey sensation inward and messages outward is interrupted.

20. Perception of external objects and voluntary motion depend upon the nerves. Though the muscles are uninjured, and all other bodily organs perfect, if the nerves are rendered inactive, the body is helpless and senseless.

Work of the Spinal Cord.

21. The spinal cord is not only a conductor of impulses to and from the brain. It is a kind of lieutenant for the brain, and relieves it of much labor. Many of our movements are unconscious. We move about in sleep. When the spinal cord is injured, so that communication between the limbs and the brain is broken, the limbs can be made to move by tickling the feet. A frog whose head has been cut off will scratch his side, if a little acetic acid is dropped on it.

22. These facts lead us to suppose that many bodily movements are made under the control of the spinal cord, the brain having only a general supervision.

23. We determine, for example, to walk to school. This is a resolve of the brain, which at once sets the muscles into action to accomplish its purpose. When we are out on the familiar street, we move without any effort of the brain. Indeed, we may be conversing

studying, or thinking, as we move along, and scarcely conscious of what we are doing. Meantime the spinal cord, the second in command, is presiding over all the complex muscular contractions that are required to carry us, leaving the brain free.

24. One who is beginning to play on the pianoforte must give close attention, and strike each note with care. The brain must direct the playing. An expert player will run rapidly through difficult passages while engaged in conversation. The spinal cord has become trained, by long practice, to do much of what at first was done by the brain.

25. Many of the lower animals are much superior to us in the use of their muscles. Their movements are more rapid and precise. Their spinal cords are larger in proportion to their brains.

26. If the brain were obliged to direct all the processes of life, and all the complex movements of the muscles, it would have neither time nor energy for its higher work.

27. The spinal cord has no sensation. All sensation, all consciousness, and all thought has its seat in the brain.

28. The nervous system will endure much. It is said that one-fifth of the blood of the body is in the brain. It is, therefore, well nourished. In starvation the brain and nerves are the last of the tissues to waste. But the nervous system is frequently abused. Tired and aching brains, weak and irritable nerves, and the condition known as nervous prostration are much more common than they should be. Since all the processes of the body depend on the nerves, all are deranged when the nervous system is out of order. Stomach, heart, and lungs are

affected. The feelings are perverted; the judgment and disposition are warped.

Sleep.

29. A great safeguard of the nervous system is sleep. Several hours in each twenty-four must be spent in sleep. An infant under six weeks of age sleeps most of the time. Children should sleep from eight to twelve hours. For adults seven or eight is sufficient. No one can endure absolute loss of sleep for many days; but many people take less sleep each night than they need. The result is, in a short time, exhaustion of the nervous system, and perhaps inability to fall asleep when they desire to do so.

Exercise.

30. Another safeguard of the nervous system is muscular exercise. Those who are engaged in outdoor manual labor seldom have nervous exhaustion. It is a disease of brain-workers, and of those whose occupation involves much care and worry, and of those who have no steady occupation. Exercise in the open air is an antidote.

What Injures the Nervous System.

31. The nervous system may be injured by over-use. The number of hours of study or other brain-work that can be performed with safety any day varies greatly for different persons. But each should learn his own limits and not exceed them. Nature gives warning of danger by headache and languor and nervousness when we are going too far. Young persons, when preparing for examination or competing for prizes, are sometimes stimulated

to do for weeks excessive brain-work, with insufficient sleep and exercise,—unconscious of the risk they run. Insanity has in some cases resulted. Worry is also more wearing than work. But worry is often a sign of overwork. The healthy brain will be undisturbed when the unhealthy one will be agitated by slight causes.

32. Over-excitement is a more common cause of nervous disorder than overwork, and the love for excitement grows with its gratification. It may be sought in reading sensational literature, in amusements, or society. In any case constant excitement is unhealthy, and begets exhaustion.

II

Effects of Alcohol, Tobacco, and other Narcotics.

1. The use of poisonous drugs, such as alcohol and tobacco, is one of the most fruitful causes of nervous disease.

2. We have seen that whenever alcohol is taken into the human system it quickly enters the blood, but does not become a part of the blood as food does. It is still alcohol, and a large part of it flows with the blood to the nerves and brain, where it soaks through the walls of the blood-vessels upon nerve and brain tissue itself. Nerve substance, which has been touched by alcohol, is at once deadened or paralyzed in proportion to the amount of alcohol reaching it.

3. We have seen that when an alcoholic liquor has been taken the heart begins to beat more rapidly, because its inhibitory nerve that should check its too rapid beats is paralyzed, and it then sends more blood than it should send to the brain. At the same time the blood-vessels

expand too much, because the nerves in their walls that should enable them to contract enough to prevent too much blood flowing through them are paralyzed. Thus, both checks that nature has provided to keep the right amount of blood in the right places are taken off by alcohol. By far too much blood then rushes to the head. It is a law of physiology that an increase in the amount of blood in any organ of the body increases the activity of that organ. Therefore, when the blood begins to rush into the brain the brain is at once excited. It may then act more rapidly than before; but it is evident to an observer that this increased activity is not trustworthy.[1]

Alcohol Injures the Judgment.

4. An important work of the brain is to consider whether the suggestions the mind receives are right or wrong, whether they are wise or unwise. This faculty of the brain, which is called judgment, is impaired by alcohol in proportion to the amount taken. A man's words may be more rapid and his imagination more active after he has taken wine, but he has not as good control over his thoughts. His imagination is likely to

[1] Sir Andrew Clark, one of the leading medical men of London, England, and physician to Queen Victoria, says: "Every man who comes to the front of his profession in London is marked by this one characteristic, the more busy he gets the less in the shape of alcohol he takes, and his excuse is, 'I cannot take it and do my work.'"

Another eminent English medical man says: "All alcohol and all things of an alcoholic nature injure the nerve tissue *pro tempore,* if not altogether. You may quicken the operations, but you do not improve them."

lead him to make statements that are not true. At such times he indulges in foolish remarks; he is often quick to take offense, and worse still, makes himself disagreeable to those about him, because his power of discrimination and his sense of propriety are diminished.

Alcohol Weakens the Will.

5. When the judgment has concluded as to the right or wrong, the wisdom or folly of a suggested act, the mind then decides what shall be done. This power of the mind which decides and guides action is called the *Will*. One of the worst effects of alcohol upon the mind is its power to weaken and finally destroy the will. The poor drunkard, in his sober moments, stung with pain over the ruin his intemperance has brought to himself and his family, often determines that he will drink no more; but under the power of appetite his weakened will yields to temptation, because it is not strong enough to carry out his good resolution. The time when a man *could* stop drinking, if he *would*, may be followed sooner than he thinks by the time when he *would* stop drinking if he *could*. This is because it is the nature of alcohol to weaken the will that should control the appetite, while at the same time it increases the appetite, making it more imperious and hence more difficult to control.

6. When wine, or any other alcoholic liquor, causes the drinker to lose control of his limbs and stagger as he walks, it is not because the alcohol "has gone to his legs," as is often said, but because it has deadened that part of his brain that has control over the action of walking.

7. All the changes in the brain caused by alcoholic drinks tend to become permanent with each repetition of the potion. There is a thickening and hardening of the substance of the brain which greatly injures the mind of the drinker.[1] "The deleterious influence of alcohol on the mental is not less marked than on the physical powers. The perceptions are blunted, the intellectual and moral faculties progressively deteriorate, until, at length, the confirmed inebriate, miserably depraved in body and brutalized in mind, has but one object in life,—namely, to gratify the morbid craving for alcohol."[2]

The Inheritance from Alcoholic Drinks.

8. It is a well-known fact that children often inherit resemblances, likes and dislikes, and other characteristics of their parents. Thus, a drinking parent often bequeathes to his innocent child an appetite for strong drink. The injurious effects of alcohol upon the brain and nerves of the drinking parent often reappear in his children, affecting their character and physical conditions. Idiocy, insanity, weak minds, weak nerves, or nervous systems liable to give way under any unusual pressure, — perverted moral natures and vicious instincts, which may manifest themselves in various ways, are all results often inherited from the use of alcohol by parents.

9. The evils inherited from the indulgence of alcoholic drinks are not confined to the children of drunkards only,

[1] Hyatt, the great Austrian anatomist, used to say that he could distinguish in the dissecting-room, in the darkest night, by one stroke of his scalpel, the brain of the dead inebriate from that of one who had lived a sober life.

[2] Dr. Austin Flint.

11. What distinguishes the human brain from that of the lower animals?

12. Is a large head a sure sign of an able brain?

13. Where is the spinal cord situated?

14. Does the spinal cord fill the canal? What is the consequence of getting a vertebræ out of joint?

15. What is the appearance of a section of the spinal cord?

16. What is a nerve made of?

17, 18. What is the work of the nerves?

19. Why are sensation and motion lost below an injury of the cord?

20. What is the condition of a person whose nerves are incapable of action?

21. What is the spinal cord besides being a conductor of impulses?

22, 23, 24. Show how the spinal cord presides over certain movements.

25. In what point are the lower animals superior to us?

26. What advantage in having the cord take part of the work of direction?

27. Has the cord sensations and consciousness?

28. Is the nervous system easily disordered? What is the result of disease of the nervous system?

29. How much time should be spent in sleep?

30. Name two safeguards of the nervous system.

31. How may the nerves be injured?

32. What is the effect of constant excitement?

II

1. What are the effects of alcohol and similar poisons on the nervous system?

2. How does alcohol reach the nerve centers?

3. How is the activity of the brain increased by alcohol?

4, 5, 6. How does alcohol affect the judgment? the will? the gait?

7. What permanent change does alcohol make in the brain?

8, 9. What inheritance may a drinking parent leave children?

10, 11, 12. What effect is tobacco likely to have on a boy who uses it?

CHAPTER XII.

THE SKIN.—BODILY HEAT.

I

1. The skin is not only a covering for the outer parts of the body; it is also an active organ, and has an important part in the processes of life.

2. As a covering it is soft, pliable, and strong. It fits the form perfectly, and in health it never feels tight. It is fine in texture and beautiful in hue.

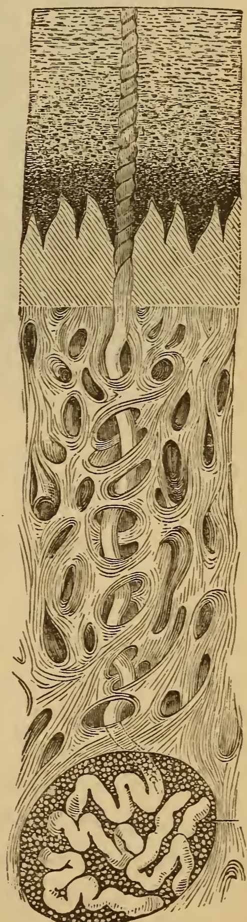
3. The lower animals, whose skins are covered with hair or feathers, are sufficiently warm without further protection. But man has a more delicate skin. Its nerves are more susceptible, especially among civilized races, and therefore he procures clothing for himself.

4. The skin is from one-fiftieth to one-eighth of an inch (.5 to .3 $^{m. m.}$) in thickness, being thickest in the palms of the hands and soles of the feet, and other parts exposed to pressure.

5. It may be divided into two layers. The upper layer is called the epidermis or cuticle. The deeper layer is the true skin or dermis. The surface of the cuticle consists of dry, fine scales which are constantly coming off, as the deeper and growing portion pushes up. The cuticle has no blood-vessels or nerves in it. This makes it a better covering, as it is insensible to slight cuts, blows, and scratches.

The Hair.

6. The hair is an outgrowth of the skin. Some of the tiny cells which form the deep layer of the cuticle, instead of being changed into dry, hard scales, are changed into hairs. Hairs are found all over the human skin, but on the larger part of it they are very short.



The Nails.

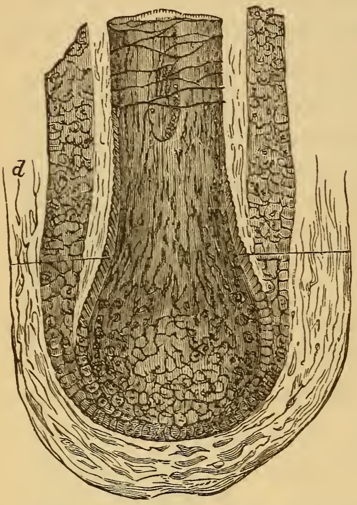
7. The nails are also a modification of the skin. These hard, smooth plates give firmness to the ends of the toes and fingers, and enable us to handle a small object better than we could without them.

8. It is in the deep layer of the cuticle that the coloring matter, which makes some skins black and others dark, in various shades, is deposited.

9. While the cuticle is without nerves or blood-vessels, the true skin or dermis is richly supplied with both. In a blister one or more layers of the cuticle are raised by water, which is gathered beneath it. If the whole cuticle is rubbed off, the dermis is uncovered, and looks raw and is extremely sensitive.

10. In a healthy skin the blood in the deep layer

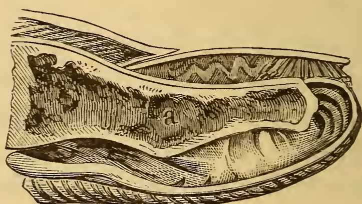
shows through the cuticle, giving it a rosy tint. In sickness, when the blood is scanty or is ill-supplied with red corpuscles, the skin looks pale and sallow. It is the life manifest in a healthy circulation that gives the bright and rosy tints, which make the skin beautiful.



11. On the palms and in other places fine ridges, lying parallel and running in different directions, can be seen by close looking. These are made of rows of little points, called *papillæ*, which rise from the surface of the dermis and show through the cuticle. The papillæ contain blood-vessels, and the ends of the nerves of touch or feeling.

The Skin a Sense Organ.

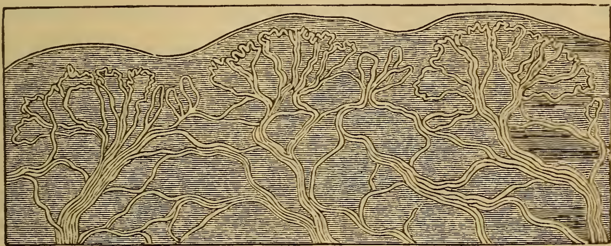
12. The skin is a most important organ of sensation. From the delicate nerve endings, which are spread all through it, messages of various kinds are carried to the brain. There are the nerves of feeling, by which pleasant or painful sensations are experienced. There are the nerves of touch, which are



more numerous and sensitive in some places — the finger-ends for example, — than in others. There are the nerves

by which we appreciate the differences in the temperature of objects touched. There are the nerves which enable us to measure the pressure with which any thing rests upon them.

13. These nerves are constantly bringing in from the skin information, abundant and various, as to objects



around us. They tell us of their size, consistency, temperature, and weight. The information of objects, which we gain through the eye, must be aided and modified by the assistance of touch. It would be a greater misfortune to lose the sensitiveness of the skin than to lose our eye-sight or hearing.

II

Bodily Heat.

1. Besides its use as a protection to the tissues beneath it and as an organ of sense, the skin has a very important office as a regulator of the heat of the body.

2. One of the most remarkable powers of the living body is the power of maintaining in itself a certain

uniform temperature.[1] It is, with very rare exceptions, warmer than the air around, and it makes its own heat.

3. If the bulb of a little fever thermometer, such as physicians carry, be placed in the mouth of a well man, and held there for five minutes, it will always mark between 97 and 99 degrees Fahrenheit (36.1 to 37.2 C.). These will be the limits in summer and winter, in the tropics and in the arctic regions. If the bulb of the thermometer could be placed in the current of the blood, the mercury would rise a little higher. It would reach about 100 degrees Fahr. (37.7 C.).

4. The body, like every other material thing, has a tendency towards the temperature of the objects around it. If it is colder than the air, or than the walls or floor of the room, or than the stove in which a fire is burning, it receives heat. If it is warmer than these things, it loses heat.[2]

5. As has already been said, the temperature of the body is commonly several degrees above that of the air. In the winter we keep our rooms at 70 degrees Fahr. (21 C.), which is thirty degrees less than the temperature of the blood. In the heats of summer the temperature of the air rarely reaches 100 degrees Fahr. (37.7 C.). It may

[1] When Lieutenant Greely was rescued after a winter of exposure to an average temperature of 5 degrees Fahr. (—15 C.), in a state of starvation, the thermometer indicated that his bodily heat was only about a degree Fahr. below the standard.

[2] A dead body seems to be much colder than surrounding objects. To the touch it is like a frozen thing. In reality it is no colder than the air of the room, or the bed on which it lies. Because it is so much colder than the living flesh, with which we unconsciously compare it, we think it colder than it is.

be said, therefore, that the human body is constantly in an atmosphere which is colder than itself.

6. The same is true of all animals. Cold-blooded animals, like fishes and frogs, are so called, not because their blood is cold, but because its temperature varies with that of the atmosphere, or the fluid in which they are. It is two or three degrees warmer than the surrounding medium. The blood of a snake in a hot sun may be much warmer than the human blood. The same animal in an atmosphere of 32 degrees Fahr. (O. C.) would have an internal temperature of 35 degrees or 36 degrees (1.6 to 2.2 C.) only.

7. The human body, then, is constantly losing heat by radiation, conduction, and convection. Since it maintains a uniform temperature it must have a source of heat in itself.

8. The three chief sources of heat are the sun, friction, and chemical action. The heat of the body is not directly derived from the sun. Friction of the blood and other moving fluids produces a little heat, but chemical action is by far the most effective cause of animal heat. When coal or wood is burned in the air, the phenomenon is called combustion. Oxygen unites with the carbon or other elements in the wood or coal, and light and heat are manifest. A slow combustion is going on all the time in the animal body. It is not active enough to make light, but it makes heat. The food that we eat may be likened to the fuel — the wood or the coal. The oxygen required is introduced by the breathing apparatus, and is carried by the blood to all the tissues. Combustion cannot go on in the body without oxygen, as a fire cannot burn without a draught. As a wood or coal

fire makes ashes, so the combustion that is going on in the body makes waste material which must be carried away by the blood, and thrown out by the lungs, skin, and kidneys.

9. The body, therefore, is in some respects like a stove or a steam-engine, in which a constant combustion is going on. When this combustion stops the body is dead, and as long as it continues heat is produced.

Clothing.

10. Except in very hot climates the body would lose its heat to the cool air faster than it made it, if we did not take some means to make up for the loss. Our clothing does not make us warm of itself, but it keeps what warmth we have in the body. The colder the outside air the thicker one's garments must be, not to keep out cold but to keep in heat. Some kinds of cloth are better for this purpose than others. Because wool is not so good a conductor of heat as cotton, a light woolen garment is warmer than a cotton one of greater thickness. Linen is suitable for our dress in hot weather, because it is a good conductor of heat and allows it to pass off from the body more rapidly than a woolen garment of the same weight. Fur and feathers are very bad conductors of heat. They are accordingly given to the birds and beasts to answer the purpose of clothing.

11. Outside of the tropics men require fires in winter to help to maintain their bodily heat. When we are chilled it is agreeable to warm ourselves by a hot fire; but ordinarily the use of the fire is not to warm us, but to keep the temperature of our rooms such that we shall

not lose heat too fast. From 65 to 70 degrees Fahr. (18.3 to 21.1 C.) is about right. In winter we eat more than in summer, and in winter we take more active exercise. By both these means our internal combustion is increased, and we produce more heat.

The Skin a Regulator of Bodily Heat.

12. The skin has in it very many blood-vessels. Cold makes them contract, and so drives the blood into the interior of the body where it is kept warm, the skin helping to retain the heat.

13. When the surrounding air is very warm, it affects the blood-vessels in the opposite way. These vessels enlarge, and the blood flows to them from the interior. Here, being near the air, it is rapidly cooled. It goes back to the interior to receive more heat, and to carry it to the skin and there again lose it to the air.

The Sweat Glands.

14. But there is another way in which the skin acts as a regulator of bodily heat, namely, through the sweat-glands. Over the whole surface are little openings called pores. There are two or three million of them in all, and in a square inch from five hundred to two thousand according to location.

15. By examining carefully with a strong magnifying glass the ridges in the skin of the fingers, the openings of the pores can be seen. There is a row of them in each ridge, the pores being at equal distances apart.

16. These pores are the mouths of the tubes. Following

one of them downward we should find that it takes a spiral course through the cuticle, it then passes directly through the dermis and terminates in a coil just underneath the skin. This coil is the sweat-gland. On its surface is a net-work of capillary blood-vessels. From these the sweat-gland draws fluid, from which it makes the perspiration that passes through the tube and appears on the surface.

17. In health the sweat-glands are always active; but ordinarily the fluid evaporates, as soon as it issues from the pores, and we do not see it. If the weather is very warm, or if we are exercising violently, perspiration flows more rapidly, and we see the drops standing over the pores, and they even run down in streams. The gentle perspiration, which is constant on a healthy skin, keeps it soft and pliable. If perspiration is stopped, the skin becomes dry and hard.

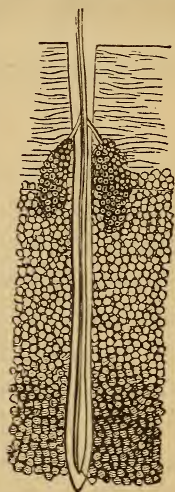
18. It is a well-known fact that when water evaporates it cools everything around it. In the change from the liquid state to the state of vapor heat is taken up. Perspiration evaporating takes heat from the skin. When the air about us is warm, or when our bodies are very warm from exercise, the blood flows to the skin and the heat of the body is reduced. When the surrounding air is cold, the blood-vessels of the skin contract,—there is less perspiration and less evaporation.

19. The skin, with its sweat-glands, is an automatic,

regulating apparatus for the heat of the body. And so perfect is its working, that the internal heat is scarcely affected by the temperature of the air. Workmen have been known to enter a room in which the floor was red-hot, and the thermometer stood at 350 degrees Fahr. (176.6 C.) without harm. Chabert, a traveling showman, used to subject himself to a temperature of 400 to 600 degrees Fahr. (205 to 315 C.). This was possible only by reason of an enormous flow of perspiration, whose evaporation prevented overheating.

Sebaceous Glands.

20. Besides the sweat-glands, the skin has sebaceous glands. Most of these are close by the root of a hair, and open into the little pit from which the hair comes. They discharge an oily matter. None of them are to be found in the palms of the hands or soles of the feet; they would make them too slippery. In other places, they serve to make the skin smooth and soft.



Muscle-Fibers in the Skin.

21. Fibers of involuntary muscle are scattered through the skin. When cold air, or a sprinkling of cold water strikes the skin, it makes these fibers contract, causing the appearance which we call goose-flesh. The hair-sacs to which the muscle-fibers are attached are pulled toward the surface, making little pin-head prominences.

22. It is plain that an organ which has such important work to do as the skin has should be well cared for.

Bathing.

23. Bathing is of great importance. Not the hands and face only, but the whole body should be frequently washed. While the watery part of the perspiration evaporates, the solid matter dissolved in it remains in the clothing and on the surface of the body. A dirty skin is quite likely to be an unhealthy skin. The pores should be kept open.

24. Not only for cleanliness is bathing valuable, but to maintain the vigor of the skin. It is full of nerves and blood-vessels and muscle-fibers. The stimulating effect of water, and the rubbing that accompanies the bath, keep these in good working order.

Colds.

25. A cold is generally the result of chilling the surface of the body. A draught strikes it, or the feet get wet, and sickness results. We spend much of our time in warm rooms, and the skin, covered by thick clothing, becomes tender. It cannot resist exposure. Those who are constantly in the open air take cold less frequently than those who live indoors. A daily morning bath in cool water invigorates the skin, and is a great protection against colds and catarrhs. The temperature of the water should be different for different persons. Those who are full-blooded and robust can use quite cold water and enjoy it. Those who are delicate must have

tepid water. A bath should always be followed by a warm glow.

26. For those whose health will not permit a daily bath, a "dry bath" is an excellent substitute. This consists in a vigorous rubbing of the skin with a towel or brush.

27. The skin may be rendered unduly sensitive by too much protection. If the clothing worn is too thick, it keeps the skin too moist and debilitates it. Fur sacks are dangerous, because they overheat the skin if kept on in a warm room, and in going out into the cold air, with the blood-vessels of the skin full and the pores open, a chill and a cold are likely to follow.

28. One who has a sore throat or sensitive lungs does well to wear a scarf, but a healthy person should leave the neck exposed in ordinary weather.

Effects of Alcohol on the Skin.

29. The skin usually becomes flushed very soon after an alcoholic drink has been taken, because, as we have seen, alcohol paralyzes the nerves in the walls of the blood-vessels, letting them stretch and hold an undue quantity of blood. The blood coming from the interior is warmer than the surface of the body, and as it rushes into the many blood-vessels of the skin a feeling of increased warmth is produced. The drinker thinks the alcohol has warmed him up. The truth is it is cooling him instead, because a larger quantity of blood than usual is near the surface of his body, where it is more rapidly cooled than in the warm, inner parts of the body. The colder the air the more quickly is this blood cooled.

The man, therefore, who takes a "gin sling," or some other alcoholic mixture, when he is going out in cold weather, is making the worst possible preparation for withstanding the cold. If he deadens his senses with alcohol to such an extent that he is not conscious of feeling cold, he is in a still more dangerous condition, for he will then be apt to neglect to properly protect himself. Travelers in frozen regions have found alcohol worse than useless as a protection against cold. They have found also that men who have weakened their constitutions, by previous use of either alcohol or tobacco, are less able to endure the severe weather than those who have never used these things.

30. Diseased conditions of the skin often result from the use of alcoholic drinks. As we have seen, alcohol injures the circulation of the blood, therefore the skin is not properly nourished and breaks up into dry scales which may stop up the pores. Unsightly blotches appear on the skin. The drunkard's red, swollen nose is often called a "rum-blossom," because, as is well known, alcohol is the cause of its enlargement.

ILLUSTRATIONS.

1. Refer to the common example of the effect of exercise and friction on the temperature and appearance of the skin. Wet a finger and hold it in a current of air, to note the cooling effect of evaporation. Refer to the apparent difference to the touch in the temperature of articles in the room, and explain this apparent difference as due to the differing power of conduction of heat in these substances. An oil-cloth *seems* colder than a carpet. Apply this principle to clothing.

QUESTIONS.

I

1, 2, 3, 4. What two uses has the skin? What kind of a covering is the skin? How thick is the skin?

5. Into what two layers may it be divided?

6, 7. What is hair? What are the nails?

8. In what portion of the skin is its coloring matter found?

9, 10, 11. What portion of the skin has blood-vessels and nerves? What is a blister? What is the cause of the ruddy or pallid appearance of the skin? What makes the little ridges seen on the skin of the palm?

12. What do we learn of things around us through the skin?

13. How is the information carried to the brain?

II

1. Mention a third use of the skin.

2, 3. What is the temperature of the interior of the body?

4. What determines the temperature of not-living objects? Does the body gain or lose heat in the same way as they do?

5, 6. What relation has the temperature of the body to that of the air? Are the lower animals like man in this respect?

7, 8, 9. Since the body is constantly losing heat, how is its temperature maintained? What are the three chief sources of heat? What is the source of the heat of the body?

10, 11. Does clothing make the body warm? What kinds of clothing are the best? Do fires make the body warm?

12, 13, 14, 15. How do the blood-vessels of the skin regulate bodily heat? How many pores are there in the skin?

16, 17, 18. What are the pores? Describe a sweat-gland and its action. How is the skin cooled by the perspiration?

19. Illustrate the action of the skin as a regulator of heat.

20. What are the sebaceous glands, and what is their use?

21. What muscle-fibers are there in the skin?

22, 23, 24, 25, 26. Why is bathing important? Why is a morning bath a good preventive of cold? What is a "dry bath"?

27, 28. How may too much clothing do injury?

29. Does a drink of alcoholic liquor help any one to keep warm?

30. What permanent effect may alcohol have on the skin?

CHAPTER XIII.

THE SENSES.—THE EYE.—THE EAR.

I

1. Our sensations may be conveniently divided into general and special sensations. General sensations are such as hunger, thirst, fatigue, restlessness, nausea, pain, pleasure, ease.

2. The general sensations are not limited to any one part of the body, nor have they any special organ.

3. The special sensations are touch, taste, smell, sight, and hearing. Each of these has a special organ.

General Sensations.

4. Hunger is referred chiefly to the stomach, but the sensation is by no means confined to that organ. It is a general craving of the whole body.

5. The same may be said of thirst. These are two of the most imperative sensations. Most people are rendered uncomfortable by the loss of a single meal. When the fast is extended throughout a day or more, the desire becomes more urgent. In times of famine it becomes a passion, which may lead men to act as though bereft of reason. Thirst is even more distressing than hunger.

6. These sensations are the forces that to a large extent direct the lives of men. The immediate object to be gained by daily work is to supply our bodily wants.

Men could not be trusted to do the work necessary to keep their bodies well nourished, if they were not impelled by a craving for food.

7. Fatigue may be felt in the muscles, or the head, or the spinal cord, or it may be a general feeling. It indicates that the body needs rest, or that it is in an unhealthy condition.

8. Restlessness or nervousness may be felt all over the body. It shows a tired or unhealthy state of body or mind, and sometimes both.

9. Nausea seems to center in the stomach, and yet it is an affection of the whole body.

10. Pain is generally distinctly localized. The nerves are more numerous in the skin than elswhere. The internal surfaces and organs are not so sensitive.[1] But most of the internal organs may be the seat of severe pain.

11. The nerves ending in the skin are, as it were, the sentinels on the outpost, whose duty it is to warn the brain of any approaching harm. The sense of pain is closely allied to the sense of touch, and has almost as good a claim to be regarded as a special sense.

12. There are certain general sensations of pleasure or comfort, such as those which follow eating, drinking, and resting. They follow exercise of the muscles and whatever heightens vital action in any part.

13. If we study the general sensations, we find that they are all designed to serve some purpose. Hunger and thirst are the means by which the nourishment of the body is secured. We should often neglect to eat; the great army of workers, who are constantly engaged in

[1] In surgical operations, cutting the skin and sewing it, cause more pain than much more extensive cuts in the deep parts.

preparing in some way for the next meal, could scarcely be kept at work but for the constantly recurring and urgent demands of hunger.

14. Fatigue is the restraining hand of nature holding us back from over-exertion. When we have used the brain, nerves, and muscles as much as they can bear to be used at one time, fatigue impels us to stop and rest. Were it not for this we might go on toiling at some absorbing labor until we had done ourselves lasting injury. We must often work when we are tired; but it should be our aim to vary our occupation, so that we shall not be excessively fatigued at any time. However tired we may be at night, if we find ourselves rested and refreshed in the morning we are safe. But if we awake weary after a night's rest, and each day adds to our feeling of fatigue, we are in danger, and we should take warning.

15. Pain is our protection from injury. An infant would burn his hand off in a flame if it did not hurt him. Children are educated to take care of their bodies by the sharp suggestions of pain. Grown people are warned by pain in the same way. Pleasure is the prevailing condition of living things. Nature inflicts pain for our good. Blows or cuts that come suddenly, without giving time enough for escape, are generally painless. Injuries that are immediately fatal are generally painless. An attack of colic causes more distress than many a mortal disease. In many, although not in all cases, where pain can serve no purpose, it is absent.[1]

[1] "After a certain degree of pain, every new breach that death opens in the constitution, nature kindly covers with insensibility," says the Vicar of Wakefield. Every one who has seen many deaths knows this to be in general true.

16. Sensations of bodily comfort and pleasure have a design as well as those of pain. They naturally accompany a condition of health, the exercise of our faculties, and the satisfaction of natural wants. They stimulate us to activity and to proper attention to our daily necessities.

17. These bodily sensations of pleasure should not be made an object in life. Those who so regard them are indolent, because they desire the pleasure of idleness; they are gluttonous and intemperate, because they desire the pleasure of eating and drinking to excess. They indulge their appetites far beyond their needs for pleasure. Such persons are called sensualists, and their course of living is always injurious alike to body and mind. It is against nature.

II

Special Senses.

1. The whole surface of the body possesses the sense of touch, and so does the lining of the mouth. Other cavities of the body have it but slightly, or not at all. It is most acute in the tip of the tongue and in the tips of the fingers. On the ends of the nerve-fibers, in some situations, are little round bodies, called touch corpuscles, which are organs of the sense of touch.

Taste.

2. The nerves of taste end in the tongue and palate. The sense is not acute in the end of the tongue.

3. There are four distinct tastes, — sweet, sour, salt, and bitter. Many of the sensations that we call tastes

are really smells. A morsel of food sends an exhalation up through the throat to the nose, and the perception of this is confounded with the genuine taste. Flavors and savors are appreciated by the sense of smell quite as often as by the taste. Repulsive medicines of some kinds may be taken more easily if the nostrils are closed while swallowing them.

4. To taste any substance it must first be dissolved in order to be absorbed by the membrane of the mouth, and so come in contact with the ends of the nerves of taste, which lie in that membrane. Insoluble substances are tasteless.

Smell.

5. The nose is the organ of smell as well as of respiration. Anatomically, the nose is not simply that prominence on the face to which in ordinary usage the name is limited. It includes also the nasal cavities, which extend back two or three inches (5 to 7.5 c. m.) and open into the upper part of the throat.

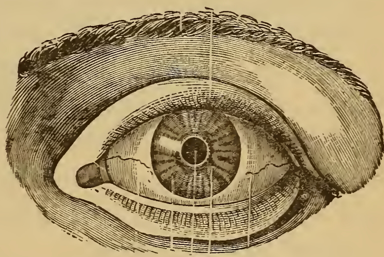
6. The nasal cavities are quite narrow, separated by a thin vertical wall in the center, and are lined with a soft, moist membrane. To the membrane lining the roof and upper portions of these cavities the olfactory nerve is distributed.

7. We perceive by smell only gaseous exhalations from odorous bodies. These are absorbed by the moist membrane, and so reach the nerve endings. The stream of air used for breathing usually passes through the lower part of the nasal cavities,—the odorous gases reach the upper part by diffusion. When we wish to smell any thing we "sniff,"—that is, we draw in forcibly a stream of air, which at once reaches the membrane of smell.

8. Colds and catarrhs blunt the sense of smell, by thickening the membrane and by covering it with an impenetrable coating of mucus.

The Eye.

9. We regard the eye and the ear as chief among our sense organs, because they give us so much of our knowledge of the world around us. A person who is blind or deaf is separated completely from many of the pleasures and activities of life, and one who is bereft of both sight and hearing has a lonely existence indeed.



10. The eyeball is nearly spherical, and is situated in a cavity in the skull called the orbit. This cavity, which is much larger than the eyeball, is well padded and lined with fat, which supports the ball in its place.

11. Just above the orbit are the arching eyebrows. These prevent the drops of perspiration which on hot days roll down the forehead from running into the eyes.

12. The eyelids are curtains of skin lined with mucous membrane, and stiffened by diminutive plates of cartilage. They are opened and shut by muscles attached.

13. The eyelashes on the edges of the lids make a light and ornamental extension of the curtains, and are useful to keep out an excess of light or dust from the eyes.

14. On the edges of the lids are the openings of some little glands that discharge an oily substance. When the

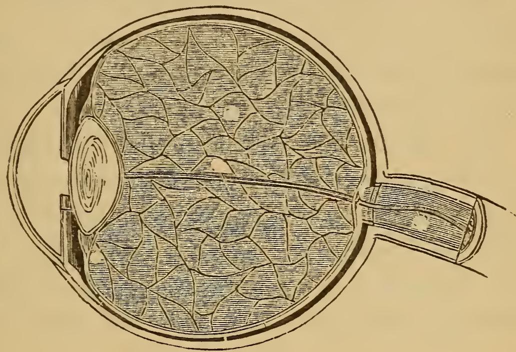
lids are inflamed this discharge becomes excessive, and drying, sticks them together during sleep. In health the discharge is just sufficient to keep their edges moistened and smooth.

15. A little almond-shaped body, lying under the roof of the orbit, is called the tear-gland. It has about a dozen little tubes, from which the tears flow out and spread themselves over the surface of the eye. When for any reason the tear-gland does not work, the eye feels dry and hot. The lids chafe it unpleasantly, in opening and closing, and it becomes inflamed. The tears are carried off through two small holes, one in the edge of each lid, near the inner angle. These open into two canals, which run towards the nose, and empty close together into the lachrymal sac. From the lachrymal sac the nasal duct passes down about three quarters of an inch (15 m.m.) and opens into the nose, where the tears are finally discharged.

16. The tear-gland is controlled by nerves which are connected with the brain. Feelings of sorrow, mortification, and sometimes of joy, cause an influence to pass along these nerves, which increases the activity of the gland. The tears flow freely, and pass down through the duct and into the nose. But in weeping the water cannot all pass off by these natural channels. Some of it runs over the eyelids and rains down the face.

17. The eyeball is a kind of *camera obscura*, like the box used by photographers in taking pictures. Its outer covering is a strong membrane, bluish-white in color. This is the "white of the eye." A thin, transparent membrane, shaped like a watch-glass, is set in front of the ball. This is the cornea.

18. Behind the cornea is the colored part of the eye, called the iris, with the round black hole, the pupil, in the center. The pupil admits the light into the interior of the eye. The iris contains muscular fibers; some running out from the center, like the radii of a circle, some surrounding the pupil. When the radiating fibers contract, the pupil is made larger. When the circular fibers contract, the pupil is made smaller. We may see the pupil enlarge when the light is dim, and grow small in the bright sunshine. We have no control over these muscular fibers. The iris is a self-regulating screen. Light and some other influences make it change itself. This is done by the agency of the nerves.

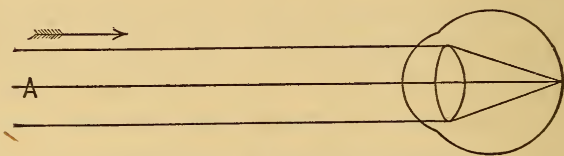


19. Back of the pupil is the crystalline lens. This is a disk-like body, with the surfaces convex. It is about one-third of an inch ($1^{c.m.}$) in diameter. It is well named crystalline, for it is clear and transparent as the purest crystal. It is but little firmer than jelly. Its use is to bring the rays of light, which pass through it to a focus on the retina, just as you have seen a glass lens (burning glass) bring the rays of the sun to a focus, so that they would burn paper. In the disease called cataract, the crystalline lens becomes hard and opaque, and some of the light cannot pass through it; the power of vision is thereby lost.

20. The eyeball behind the lens is filled with a semi-liquid matter, very clear, called the vitreous (glass-like) humor.

21. The retina is a membrane lining the back of the eyeball containing the terminal fibers of the optic-nerve. The optic-nerve enters at the back of the ball, and after passing through its outer coats, its fibers spread out in the lining membrane.

22. When you sit for your photograph a picture of your face is made upon the sensitive plate, which the photographer slips into the back of his camera. So when the eye is directed to any object, that object is pictured on the retina. As the rays reflected from your face pass through the glass lens, and fall upon the sensitive plate,



Normal eye, in vision at long distances.

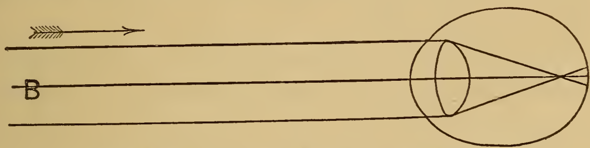
so rays pass from the object of vision through the lens of the eye and the vitreous humor, and by these are brought to a focus on the retina. The lining of the camera is always of a dark color; the retina is also of a dark color. The picture, both on the sensitive plate and on the retina, is upside down, but for some reason which we do not understand, it does not appear so to the mind.

23. It is not the eye that sees, for however perfect the eye, if the optic nerve behind it is cut off, there is no vision. It is the brain that sees; but the rays of light which focus on the retina and make this picture

stimulate the peculiar endings of the nerve-fibers which compose the retina, and these fibers carry an impression into the brain, which is vision.

Near-Sightedness.

24. In a perfect eye the rays of light are brought to a focus precisely on the retina, and a distinct picture is formed. Some eyeballs are too long from before backward. In these eyes the retina is too far from the lens. The rays of light focus before they reach it. They then cross and spread out on the retina, making a blurred image. Such eyes are called *near-sighted*, because objects held very near to the eye are seen dis-



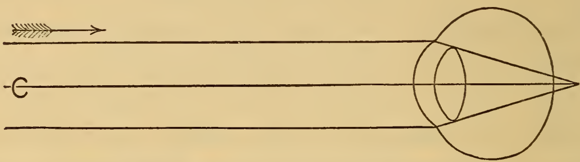
Short-sighted eye, in vision at long distances.

tinctly, and no others. When an object is very near to the eye, the rays of light reflected from it come to a focus farther from the lens than when it is at a distance. Near objects are therefore distinctly pictured on the retina of these long eyes, while distant objects are not. Near-sightedness is corrected by the use of spectacles with concave glasses. These glasses change the direction of the rays of light, so that they do not come to a focus until they reach the retina.

Far-Sightedness.

25. Some eyeballs are too short from before backward. The retina is too near the lens. The rays of light reach

the retina before they have come to a focus, and thus a blurred image is formed. Such eyes are called *far-sighted*, because objects at a distance form a more distinct image than near objects. Rays of light from a distant object



Far-sighted eye, in vision at long distances.

come to a focus nearer to the lens than those from a near object. Convex glasses are the remedy for far-sightedness. They change the direction of the rays, so that they will focus on the retina.

26. Near-sighted people do not as commonly have pain in their eyes as far-sighted people. Inflammation of the eye and headaches are frequently caused by this latter defect. That is because the far-sighted eye can by an effort change its shape so as to correct its defect. Making this effort constantly, the eye becomes fatigued and irritated, and the neighboring nerves sympathize. Those who have near-sighted eyes cannot remedy their defect in this way, and make no effort to do so.

27. Children are frequently "far-sighted," and suffer from headaches after studying. When this takes place, it is wise to have the eyes tested by an oculist.

Old-Sight.

28. After forty years of age, the lens loses its elasticity and cannot focus for near objects easily. Distant objects may be seen clearly, but for reading or other close work

convex glasses must be used. This is called *old-sight*, and does not imply any imperfection in the shape of the eye.

29. If there is any reason to suspect that the eyes are imperfect they should be tested by an oculist, and the oversight corrected as soon as possible. It irritates and wearies and weakens an eye to contend with its defects.

Care of the Eyes.

30. The eye is worthy of more care and thought than some other organs, because it is so delicate and so valuable. Those whose occupation requires close use of the eyes should be especially careful of them. The following suggestions are important: —

(*a*) As to light, — the light should be sufficient. It strains and tries the eyes to read with a dim light, and above all, with a fading light — like twilight. Schoolrooms and offices should have plenty of window-space. It should equal from one-sixth to one-third of the floor area. The light should not be too glaring. When it is strong, it should be tempered by shades or blinds. The light should fall, if possible, over the shoulder. For writing it should fall over the left shoulder The shadow of the hand will not then be thrown upon the point of the pen. The light should be steady, — a flickering light is very trying.

(*b*) It is bad to read when lying down.

(*c*) It is bad to read when in motion, as when riding. The constant movement of the type stimulates the eye to follow it, by a constant movement of its own, which is wearisome.

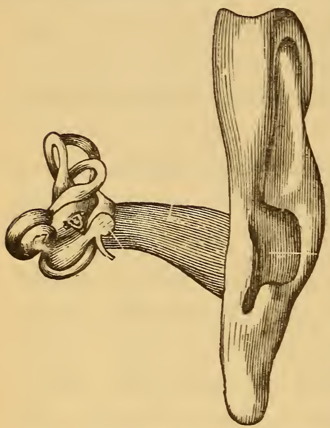
(*d*) It is bad to read or write when the eyes are tired. A smarting of the lids, a feeling as of sand in the eye,

and an aching of the eyeballs are symptoms which call for rest.

(*e*) Any trouble with the eyes should be brought to the notice of a physician.

The Ear.

31. The essential part of the ear lies deep in one of the bones of the skull. The flexible appendages, which we call the ears, are only the open ends of two tubes that carry the sound inward to the drum. These tubes are an inch (2.5 c. m.) long. The outer half is made of cartilage; the inner half of bone.



32. At the end of these tubes the drum-head is stretched across the passage. This is a very thin membrane which vibrates as the waves of sound strike it.

33. Behind the drum-head lies the shallow cavity, called the drum or middle ear. In order that a drum-head may vibrate freely, and make a clear sound, there must be a hole in the side of the drum. In the drum of the ear this necessity is provided for by a tube (the eustachian tube) passing from the ear to the throat. A cold in the head or a chronic catarrh will sometimes close this tube. Deafness results, which is relieved often very suddenly, when the tube is opened.

34. The drum contains three little bones (the smallest in the body), united by joints in a chain, which is

attached at one end to the inside of the drum-head: at the other end to a membrane which covers a passageway to the inner ear. As the drumhead vibrates, the motion is imparted to these bones, and carried by them to the inner ear. These bones are not absolutely essential to hearing. Persons who have lost the drum-head and the little bones can still hear, but not well.

35. The internal ear is lodged in a bone, which, because it is so hard, is called the petrous bone (*petros*, a stone). The external and middle ear serve to conduct sound to the internal ear. Here is the ending of the auditory nerve that receives the impression of sound. If the auditory nerve is cut no sound is heard, though the ear is uninjured. It is the brain that hears, and not the ear.

36. Sound is a vibration that can be recognized by the ear. Fishes have no external ear. The vibrations are conveyed through the bones of the head to the nerve ending in the internal ear. They may be carried to our ears in the same way. Audiphones and similar instruments held between the teeth are set in vibration by sound; the vibration is sent through the teeth and skull to the internal ear. This kind of hearing is not at all acute, but better than none.

37. These instruments are useful only when the deafness results from obstruction in the external or middle ear. If the internal ear alone is defective they are quite useless.

Care of the Ear.

38. The best way to take care of the ear is to let it alone. No one should put any instrument into his ear for cleaning or any other purpose. There is danger of irritating and injuring it.

39. It may be gently syringed out with warm water, if necessary. If any thing lodges in the ear, it should be removed by a physician. A soft towel and the ends of the fingers will suffice to keep it clean.

40. The ears should never be boxed. The drum membranes may be ruptured in this way.

41. It is wise in cold, windy weather to put a bit of cotton into the ear to protect it. This is especially important for those who are subject to catarrh, or are in delicate health.

42. Any one who has a constant discharge from the ear should consult a physician about it without delay.

Effects of Alcohol upon the Senses.

43. All the senses are more or less dulled by the action of alcohol upon the nerves. If alcohol is taken habitually, its blunting effect is a constant menace to the senses. The organs of taste that are frequently subjected to the irritating effects of alcohol or tobacco become incapable of tasting delicate flavors. Food for such a person must be highly seasoned, or he pronounces it tasteless and not "fit to eat." The sight may become dimmed by the use of alcohol and tobacco, and blindness result. Abstinence from both is followed in most cases by the restoration of the eye-sight.

ILLUSTRATIONS.

1. The eye of an ox or some other animal from the butcher will illustrate the structure of the human eye. Point out the cornea, iris, and pupil. Cut the ball open, and show the lens, the vitreous body and the retina.

2. The internal ear may be shown by a careful section of the temporal bone, in which it is situated.

QUESTIONS.

I

1, 2, 3. Into what two classes may sensations be divided? What are general sensations? What are special sensations and where are they located?

4, 5. To what part of the body is the sensation of hunger referred? of thirst? Which is the more urgent?

6. How do hunger and thirst keep the world active?

7, 8, 9, 10. What is the location of fatigue? of restlessness? of nausea? of pain?

11. Why should the nerves of pain be more numerous on the surface than in the interior of the body?

12, 13, 14, 15. What purpose is served by the sensations of hunger and thirst? of fatigue? of pain?

16. Have pleasurable sensations a design?

17. Should pleasurable sensations be made an object in life? What is a sensualist?

II

1. What is the organ of touch?

2. What is the organ of taste?

3. What are the tastes? What has the nose to do with taste?

4. In what condition must a substance be in order to be tasted?

5, 6. Describe the nasal cavities. What is the nerve of smell called?

7. In what condition must a body be in order that we may smell it?

8. How do colds and catarrh blunt the sense of smell?

9. To which of our sense organs do we give the first place?

10, 11, 12, 13, 14. Describe the orbit; the eyeball; the eyebrows; the eyelids; the eyelashes; the glands of the lids.

15. Where do the tears come from? Where do they go?

16. How is the action of the tear-gland controlled?

17. What instrument is like the eye in structure? What is the cornea?

18. What is the iris? the pupil? How is the size of the pupil changed?

19. What is the lens? What is a cataract?

20. What is the vitreous humor?

21. What is the retina?

22. In what respect is vision like taking a photograph?

23. Is it the eye that sees?

24. What is near-sightedness?

25. What is far-sightedness?

26. Who suffer most from pain and discomfort in the eyes,—near-sighted or far-sighted people?

27. Name one effect of far-sightedness.

28. What is "old sight"?

29. Why should an oculist be consulted if the eye is defective?

30. Give five rules for the care of the eyes.

31. Where is the essential part of the ear? What is the use of the part which is in view?

32. What is the drum-head?

33. What is behind the drum-head? What is the "hole" in the drum?

34. Describe the bones of the ear and their use.

35. How is the internal ear protected? Does the ear hear?

36. What is sound? How do fishes hear?

37. How are audiphones useful?

38. How shall we take care of the ear?

39. What should be done if anything lodges in the ear?

40. Why is it wrong to box the ears?

41, 42. What precaution should be taken by those who have sensitive ears?

43. How does alcohol affect the senses?

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